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First Class-Book

OF

PHYSICAL GEOGRAPHY,

BY

WILLIAM RHIND.

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2011 f. 55

FIRST CLASS-BOOK

OF

PHYSICAL GEOGRAPHY.

MURRAY AND GIBB, PRINTERS, EDINBURGH.

FIRST CLASS-BOOK

OF

PHYSICAL GEOGRAPHY:

EMBRACING

DESCRIPTION OF THE EARTH, ATMOSPHERE, OCEAN,

AND

DISTRIBUTION OF PLANTS AND ANIMALS.

BY

WILLIAM RHIND,

AUTHOR OF "ELEMENTS OF GEOLOGY AND PHYSICAL GEOGRAPHY;"
"ELEMENTS OF ZOOLOGY."

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"IN THE BEGINNING GOD CREATED THE HEAVEN AND THE EARTH."

"O LORD HOW MANIFOLD ARE THY WORKS!
IN WISDOM HAST THOU MADE THEM ALL."

ADVERTISEMENT.

THESE Elementary Principles of Physical Geography are intended merely as a Text Book to the Pupil and Teacher of the Science; while the subjects of the different Sections are to be filled up and illustrated by oral demonstration. A few explanatory Diagrams are given; but larger Maps and Diagrams are necessary for full explanations; and a series of these are in course of preparation by Mr A. K. Johnston, Edinburgh.

The subjects here treated of, are such as a long experience in lecturing has convinced the Author are fully appreciable by Pupils of Ten years of age and upwards; and a preliminary knowledge of which he conceives to be essentially necessary for the true understanding and successful study of the otherwise dry and abstract details of Geography, as commonly taught.

The present Class-book relates chiefly to INORGANIC NATURE; another of similar size will embrace a view of ORGANIC LIFE, as manifested in Plants and Animals, with their distribution over the Earth's surface.

The Author has availed himself of the extensive experience of Dr Alexander Reid, late of the Circus Place School, Edinburgh, in rendering the present Work suitable for the purpose of Class Teaching.

Several Tables, containing brief descriptions of the Thermometer, Barometer, and Rain Gauge, with an explanation of the strictly Technical Terms which occur in the Treatise, and a List of Works to be consulted, are given in the Appendix; as also Tables of Temperature and other subjects alluded to in the Work.

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CLASS-BOOK

OF

PHYSICAL GEOGRAPHY.

SECTION I.—GENERAL VIEW OF THE EARTH.

Physical Geography embraces a view of the earth, its atmosphere, ocean, mountains, valleys, rivers, and the distribution of plants and animals over its surface.

The earth is one of the planets which form the solar system; one of the "six wandering stars," which were known to Galileo; and one of seventeen planetary bodies, now ascertained to revolve round the sun as a centre.

(See Appendix II).

The earth makes a great revolution round the sun in a solar year of twelve months. It also makes a daily revolution round its own axis in about twenty-four hours.

The earth is connected with the solar system by the prevailing power of gravity, and receives from the sun the influence of the solar rays; these producing light and heat; and, in all probability, electric and magnetic actions.

In other respects the earth forms a complete system within itself, continually upheld by the power of its Creator; but needing no additional matter from without; and, though incessant changes are taking place on its surface, yet no particle of its matter is wasted or destroyed.

The form of the earth is that of an oblate spheroid, elevated somewhat at the equator, and depressed at the poles. This is the form which all fluid bodies assume when revolving freely in space.

The diameter at the equator is 7927.4 miles, at the poles 7899.6 miles, and the excess of the elevation of the equatorial region, therefore, amounts to 13.9 miles.

The earth is 5 times (5.6) heavier than a globe of water of equal bulk would be. But the rocks which form the surface of the earth are only from two to three times heavier than water. It is probable, then, that the earth increases in density from the surface towards the centre.

The mean circumference of the earth is 24,861 miles, which, multiplied by the mean diameter 7913.5 miles, gives 196,737,523 square miles, as the extent of the whole surface of the globe.

The earth is surrounded by a zone of air called the atmosphere, which extends to the height of from forty-five to fifty miles.

It is also surrounded by an ocean of water, whose depth varies from 100 feet to 1, 2, and 5 miles.

The dry lands of the earth are those more elevated portions of its mass which rise above the surface of the ocean, and which form continents and islands. The highest peaks of this land reach the height of 5½ miles, but the habitable plains and valleys do not generally rise above from 100 to 500 or 1,000 feet. The medium height of the continents of Europe, Asia, and America, being about 1,000 feet.

An intimate connection subsists between the atmosphere, the ocean, and the land; and in these a never-ceasing series of operations are performed, which are essentially necessary for the existence of plants and animals on the earth's surface. And thus it is, that the system of the earth, or of nature, forms one great whole.

The same elementary substances, too, or kinds of matter, enter into the composition of the air, water, earth, plants, and the bodies of animals.

The most common elementary substances are enumerated in Appendix No. III.

SECTION II.—METEOROLOGY, OR HISTORY OF THE ATMOSPHERE.

The atmosphere, or vapoury sphere above us, appears, when we look around, a vast dome, and circular, because objects far removed from the eye appear all at a uniform distance, and thus assume a circular arch, of which the eye is the centre. Yet the extreme height of the atmosphere does not exceed fifty miles; and its denser portion, containing all the clouds and vapour, is not higher than 4 miles.

A line drawn from the earth's centre to its surface is nearly 4,000 miles — the height of the atmosphere is 50 miles, or about one-eightieth of the earth's radius.

The atmosphere presses upon the earth's surface with a weight of 15 pounds on every square inch, or nearly one ton on a square foot; but its pressure, being equable on all sides, is not felt by us under ordinary circumstances.

Air being an extremely elastic and compressible body, the lower portions of the atmosphere, receiving the pressure of those above, are denser and heavier than the upper.

This is exemplified by placing half-a-dozen books upon each other; when it will be seen that the lowest book has the pressure of five books, the second of four books, the third of three books, and so on.

The last, or highest portion of air, has no incumbent pressure, and would, from its elastic nature, fly off into space were it not restrained by the force of attraction which draws it towards the earth.

The atmosphere has thus a regularly defined limit all around the globe; and beyond this we can only conceive the space of the universe.

The atmosphere is composed of 3 gases or airs, and 100 parts contain of—

Nitrogen, . . .	79 parts.	Or nearly
Oxygen (vital air), .	21 parts.	4 1.
Carbonic acid from	$\frac{1}{100}$ to $\frac{1}{1000}$ part.	

These gases are mechanically mixed, not chemically combined; exemplified in mixing portions of sand of three colours, where the particles, though mingling together, remain distinct. Each gas, too, retains its own elastic force, and thus nitrogen expands most, or highest; oxygen next; and carbonic acid least.

The air contains also a varying portion of watery vapour, generally about one hundredth part, and of ammonia and other animal effluvia; but it preserves the same general composition throughout every region of the globe.

A column of air the whole height of the atmosphere, is balanced or weighed by a column of quicksilver of 30 inches high, or by a column of water of 35 feet (1 to 13.6).

If the pressure of the air is diminished or becomes lighter, the column of quicksilver, necessary to balance it, is less than 30 inches; if the pressure of the air is increased or the air become heavier, a column of more than 30 inches is required.

It is on this principle that the barometer (a measurer of the weight of air) is formed.

A description of this instrument, and its general indications of change in the atmosphere, are given in the Appendix No. IV.

SECTION III.—TEMPERATURE AND AIR-CURRENTS. PERPENDICULAR TEMPERATURE OF THE ATMOSPHERE. GLACIERS.

The earth's surface receives its heat solely from the sun.

During the day the sun-beams fall upon the surface of the earth, and heat is absorbed; at night this heat is *radiated* or given out again into space, so that heat, on the whole, does not accumulate on the earth.

The hottest time of the day is two or three hours after noon; the coldest time is an hour before sunrise.

The sun's heat does not penetrate deeper into the earth than from 40 to 60 feet in the temperate climates. At these depths a uniform temperature prevails throughout the year, and this temperature, or that of common springs, will be found to agree with the mean annual heat of the air of the particular locality.

In the frigid zones the sun's heat does not penetrate beyond the depth of 3 feet.

The solid surface of the earth has a greater capacity for absorbing the sun's rays than air. The sun-beams pass readily through the atmosphere, especially the higher and rarer parts, and little more than a third of their heat is absorbed.

Water readily absorbs the sun's rays, but it gives out or radiates heat slowly. The atmosphere, then, is mainly heated from its lower portion coming in contact with the heated surface of the earth.

A bare, rocky, or sandy surface, absorbs more heat than a soil covered with dense vegetation, especially tall trees. A dark soil, or dark rock, absorbs heat more readily than white or light coloured.

The lower part of the atmosphere, thus acquiring heat from the earth, becomes lighter and more elastic, and mounts upwards; its place is supplied by portions of colder and heavier air; and this is the primary cause of all movements in the atmosphere, which otherwise would remain uniformly still and unagitated.

There are two great currents which continually prevail in the atmosphere, and these arise from the unequal heating of the earth's surface.

For a certain space on each side of the equator the sun shines with full vertical rays. In this space the greatest amount of heat is absorbed, and hence it has been termed the *Torrid Zone*. Receding from the boundary of this zone, on each side toward the poles, the sun's influence gradually diminishes, and a certain space, north and south, has been termed the *Temperate Zone*. Around each pole are the *Frigid Zones*, where the temperature is still more diminished.

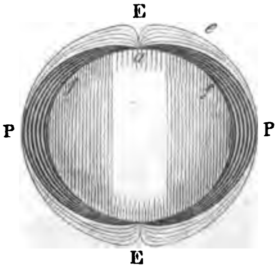
The Torrid Zone occupies a space of 23½ degrees on each side of the equator, thus forming a belt of 47 degrees in breadth. The temperate zones, N. and S. of the torrid zone, occupy a space each of 43 degrees. The frigid zones occupy a space of 23½ degrees around each pole; the north frigid within the arctic, and the south frigid within the antarctic circle. A degree is 60 geographical miles, or 69 English miles, and is divided into 60 minutes and 60 seconds, marked thus :—23° 30′ 1″.

The solar heat then is greatest at the equator, and decreases towards each pole.

Where the sun shines vertical, or nearly so, the whole of his rays fall on the earth's surface, and are absorbed; where the sun is lower, his rays fall in a slanting position, part only reach the earth's surface, the remainder pass through or beyond the atmosphere, and leave little of their heating effects.

This is more particularly explained, Sect. IV., p. 20.

The lower portion of the air in the torrid zone, then, becomes heated by contact with the earth's surface; it mounts up and forms an upward hot air current, while a stream of cold air rushes in from each polar region to supply the place of the upward equatorial stream, and thus two opposite currents prevail, one of heated air rising up from the equator and flowing towards the poles; another cold and heavier current pressing from the poles towards the equator.

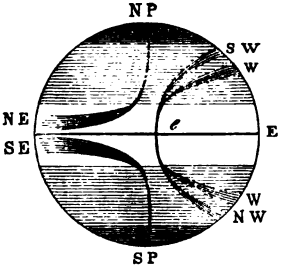


Thus the central circle represents the earth, P P the poles, E E the equator, E *e* P is the current of heated air rising from the equator and passing to the pole, P *f a* is the polar current pressing to the equator.

The true cause of this movement is, that air when heated becomes light, while cold air is heavier — thus the heavy cold air presses from the polar spaces and dislodges the hot light air, which in its turn is pressed toward the poles and again cooled.

Were the earth motionless, these currents would blow due N. and S.; but in consequence of the earth's daily rotation from W. to E., the currents have a direction N.E. on the northern hemisphere, and S.E. on the southern.

The earth at the equator moves daily at the rate of 1000 miles an hour from west to east; but this motion diminishes in advancing to each pole, at lat. 60° it is 500 miles, and at last, at the pole itself, it becomes as imperceptible as the motion of the hour-hand of a clock. The current of wind then coming from the poles has less velocity than the surface over which it travels, so that the earth moves eastward much faster than the air, and it is thus left behind—in other words, it becomes, instead of a due north current, a north-east. The reverse is the case with the upper tropical current. Its velocity is greater than the surface of the earth above which it travels, so that as it advances northwards it outstrips the earth's motion, and becomes a S.W. and W. wind.



In this diagram, E *e* is the equator; N P, the north pole; S P, the south pole. The current of wind coming from the N. is seen to diverge to N.E. as it enters the line of the torrid zone, while the S current turns to S.E. in the same manner. The upper current starting at *e* with an equatorial velocity of 1000 miles an hour, as it advances northward outstrips the velocity of the temperate zone, and becomes a S.W. and W. wind. In the southern hemisphere, it becomes a N.W. and W. wind. This diagram explains also the cause why the wind has a tendency to take a circular course; and to veer from N. by E. and S. to W., and again N.

Within the limits of the torrid zone these currents are constant and uniform, and produce the well-known *Trade-Winds*.

Beyond the limits of this zone the currents are liable to various interruptions; yet, throughout the range of the temperate zones, and a portion of the frigid, the S.W. and N.E. winds are those which usually prevail, and not unfrequently the upper and lower currents blowing in adverse directions, become distinctly apparent by one set of clouds passing north and another south.

When two opposite currents meet, a calm ensues, because the opposite forces are neutralized by each other.

The trade-winds prevail from the 28° to 30° of lat. N. and S. of the equator, varying somewhat as the sun is N. or S. of the equator. Immediately under the line of the equator, for a space of 5°, is a region of calms or slight variable winds.

The *Monsoons* are somewhat similar to the trade-winds, only they are periodical, and not constant. An extensive continental region within the range of either tropic becomes heated while the sun is vertical over it; in this way an upward current of heated air is produced, while a cold current from the neighbouring ocean blows towards the land, and continues to blow for a certain time every year, and in some localities twice a-year, constituting the monsoon.

The monsoons prevail on the eastern coasts of Africa, on the east and west coasts of Hindostan, and on both coasts of the Malay Peninsula, in Eastern Asia.

The Sirocco, or Mediterranean wind, a hot current blowing over N. Africa, is somewhat of the nature of the monsoon; and the simoom, or hot wind of the sandy desert, has a similar origin.

In hot summer days, in maritime countries, the land becomes heated, and the hot air ascends, while a current of air comes from the colder ocean, causing the grateful *sea-breeze.*

At night, again, the earth cools by radiation more quickly than the ocean, and a land breeze blows towards the sea.

A current of wind blowing with the velocity of 5 miles an hour forms a gentle breeze; a rate of 15 miles an hour causes a brisk gale; from 30 to 40 miles an hour is a high wind; from 80 to 100 miles forms a hurricane.

Hurricanes and tremendous thunder-storms, with torrents of rain, accompany the setting in of the monsoons, or at that period when the sun becomes vertical over the particular portion of continental land where they prevail.

Hurricanes are caused chiefly by electric changes in the air, to be explained afterwards.

The denser the air, the greater is its capacity or power of retaining heat. Hence the lower parts of the atmosphere being, from position, the densest, are warmer than those higher up.

The higher we ascend into the atmosphere, the colder the air becomes; and thus the summits of high mountains are covered with snow, while at the base a tropical heat may prevail. Examples of this are found in the Himalaya mountains of India, and the Andes of South America.

The temperature of the atmosphere is measured by the thermometer—(explained in Appendix, No. IV). Water freezes at 32° of Fahrenheit's scale. 86° is summer heat; 98° blood heat, or ordinary heat of the body. The mean or medium temperature of the year, is the average of all the months added together, and divided by 12; and the mean temperature of any particular place is ascertained by taking the average of a number of years.

The point in the atmosphere where congelation commences is called the lower limit of the snow line, or line of perpetual congelation.

The height of this line varies according to latitude.

In the vicinity of the equator it is highest, and it falls lower and lower towards each pole, where it is found at the earth's surface.

The mean elevation of the snow line at the equator is 15,000 ft.
About the middle of the temperate region, in lat 45°, it is 8,500 ft.
At the boundary between the temperate and frigid zones, lat. 66° 30′, 4,000 ft.

(See Table, in Appendix No. V).

The snow line varies somewhat according to the nature of the earth's surface, so that the line of the equator is not invariably its highest point.

Thus, on the north side of the Himalaya mountains, the snow line is at the height of 16,000 feet, while on the south side it is 15,000 feet. Because on the south side the contiguous ground is a depressed valley, whereas on the north is the extensive and elevated table-land of Tibet, where heat is absorbed and communicated to the surrounding air. (See Diagram, p. 68).

This variation of temperature, according to height in the atmosphere, gives rise to a variety of climate even within the same mountain range; so that a mountain within the torrid zone has at its base a tropical climate, in its middle a temperate region, and at the top an arctic or frigid climate.

Even in the temperate zones, this is to a certain extent the case. The summits of the Alps are covered with snow during the warmest summers, and snow always lies on the summit of Ben-Wyvis, in Scotland.

This circumstance has a remarkable influence on the localization of plants and animals,—these organic beings invariably obeying the laws of climate in their distribution.

Glaciers are formed on the sides of snow-capped mountains; and consist of masses of half melted snow and ice, which have an onward progress, more or less quick according to the temperature of the season. In winter they are almost motionless,—in summer they move down the slopes of the mountains, carrying along with them mud and stones (which, accumulating, form *moraines*), till at last they terminate in a running stream.

SECTION IV.—DISTRIBUTION OF HEAT. THE SEASONS.

As a general law, the greatest degree of heat prevails within the tropical or torrid zone, and this heat gradually diminishes towards either pole. But this law has modifications.

The surface of the land both accumulates and imparts heat more readily than the surface of the sea—hence continents exposed to the full solar influence have a higher temperature than ocean tracts or islands surrounded by sea. The continent of Africa, and the central parts of Asia, as India and China, have a higher temperature than any of the contiguous islands, in corresponding latitudes.

Places in the same parallel of latitude, then, do not all enjoy equal degrees of temperature.

A line pointing out equal degrees of temperature for the whole year is called the *Isothermal Line*, or line of equal temperature.

The isothermal lines are to be pointed out on large diagrams, or lines drawn on a common map, by the teacher.—(See Table of Temperatures, Appendix No. VI.)

Thus, New York, in the United States of North America, is eight degrees of latitude nearer the equator than London. But New York forms part of a large continent, while Great

Britain is an island. The mean annual temperature of New York is 51° .6; that of London is 50° .6. So that a line drawn to include both would be one very different from a parallel line of latitude.

As a general rule, in regions not tropical, almost all situations placed in large continents have greater extremes of summer and winter temperature than insular situations; or their summers are much hotter, and their winters much colder, than the corresponding seasons of islands.

	London.	N. York.	Jakutsk, Siberia.
Mean annual summer temp.,	62°.8	70°.3	61°.7
... ... winter temp.,	39 .3	30 .1	—36 .3
... ... temp. of year,	50 .6	51 .6	13 .5

This arises in continents from their large surfaces absorbing more of the sun's rays in summer, and thus forming above them a warmer atmosphere than what takes place in islands surrounded by the sea; while, on the other hand, in winter, the sun's influence being diminished, the temperature of continents falls greatly below that which prevails in islands surrounded by an ocean of medium temperature.

(See Section on the Ocean.)

The southern hemisphere having less extent of land, especially in its torrid and temperate zones, is considerably below the mean temperature of the northern hemisphere.

The mean annual temp. of the torrid zone is, in the old world, 84°; in the new world, 81°. The mean annual temp. of the N. temperate zone is 54°. In lat. 55° to 65° in the southern hemisphere, corresponding to the N. of England, Scotland, and Norway, there is perpetual frost all the year, and the most scanty traces of vegetable life; beyond 60° S., vegetation ceases entirely.

The hottest parts of the earth exhibit a temperature of 110° to 120°, while a thermometer placed in the hot tropical soil of India, will rise to 144°.

The greatest degree of cold in the habitable regions of Greenland is 40° below zero. The mean winter cold of Quebec, in Canada, is 14°, or 18° below the freezing point of water.

In the N. hemisphere there are two points of greatest cold, in the parallel of 80°. One in long. 95° E., the other in long. 100° W.

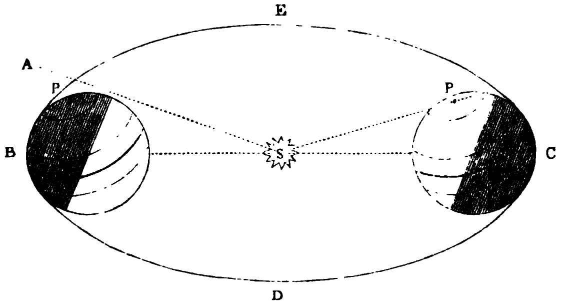
In the torrid zone a nearly uniform degree of heat prevails throughout the year. And this heat is equal to 82°.5 of the thermometer. The day and night, too, are of equal length, being 12 hours each.

In the temperate and frigid zones there is a succession of seasons, and an inequality of day and night.

In the great annual circle which the earth makes round the sun, its axis is inclined to the plane of the ecliptic at an angle of 66° 30′, so that the N. pole points always to one spot in the heavens.

In the northern hemisphere, the north pole is inclined towards the sun during the summer half of the year, and thus the sun's rays fall on the surface more directly, and in greater quantity, while the day is much longer than the night; hence heat accumulates, causing our warm seasons. The hottest part of the season generally commences about 3 or 4 weeks after the longest day.

In winter the N. polar axis is turned from the sun, so that his rays fall in a slanting manner on the surface, and the greater proportion pass through the atmosphere without falling on the earth at all. The day, too, is short, and the night long.



In this diagram, B is the winter position of the earth, as respects the northern hemisphere, when the sun's position is said to be low. A portion of his rays, as S A, in this position, do not fall upon the earth's surface at all, but pass over it. In the summer position, C, where the north pole is turned more directly towards the sun, all his rays, from S P to S C, fall on the northern hemisphere. The winter position, B, of the northern hemisphere, becomes the summer position of the southern,—and the southern winter prevails during the north summer position, C. When the earth reaches the equinoctial points, E and D, in the great annual circle, one half of the globe, from pole to pole, is equally illuminated.

The low position of the morning and evening sun relatively to the earth, also affects the daily temperature; because at those times a great proportion of the sun's rays pass *over* the earth, or through the atmosphere only; while, at mid-day, the whole rays fall directly on the surface of the soil. Little of the heat, even of the most slanting rays, is actually reflected or lost, either from the earth or ocean; and it is of importance to explain these facts to the pupil, as many books, in frequent use, make a very different statement.

Had the axis been perpendicular there would have been no succession of seasons; but then, in Great Britain the temperature would never have risen higher than that which occurs on the 22d of March and the 22d of September—a temperature, quite insufficient to bring to maturity any of the fruits of the earth; while to the north of Britain, the temperature would have decreased greatly, and thus a great part of the present habitable globe would have become unfit for supporting life. The present arrangement, on the contrary, admits of the greatest possible diffusion of heat and life over the earth's surface.

A globe of wood, divided by lines into zones, and carried round a burning taper, will sufficiently represent the earth's positions and successive changes of seasons.

In the temperate zones, there are in all seasons sudden alternations of heat and cold. And these arise mainly from the prevalence of either north and north-east winds, or south and south-west winds; from high winds causing sudden evaporation, or calms preventing evaporation, as also from electric influences affecting the pressure of the atmosphere.

A few islands happily situated, as Madeira, the Canary Islands, and some of those of the South Sea, enjoy a perpetual spring.

SECTION V.—EVAPORATION, CLOUDS, RAIN.

The air always contains a portion of watery vapour suspended in it, varying with its temperature.

Water, in common with all fluids, has a tendency to pass up into the air in the form of extremely minute particles, or vapour, and this vapour is suspended amid the particles of air, in the same way as water is held suspended in the pores of a sponge.

This evaporation is continually taking place from the surface of the ocean and the moist soil of the earth; it is excited in the first instance by heat, and accelerated or retarded by the degree of temperature of the air, and other causes.

Thus a hot and dry air accelerates evaporation. A current of air passing rapidly along the surface increases evaporation, as in the case of winds. A calm stagnant and moist air greatly diminishes evaporation. The highest degree of evaporation is exhibited in a vessel of water boiling over a fire. Steam condensing is visible vapour.

The rate of expansion of vapour differs from that of air.

Heat being the great exciting cause of evaporation, this process is greatest in the torrid zone, and diminishes towards the poles.

The air, even at a high natural temperature, can only contain a certain proportion of vapour, about one-hundredth part; and it can retain this, or any less proportion, without its pure transparent aspect being impaired.

The stratum of air next to the surface of the ocean or land is the first to receive the particles of moisture. This stratum at the same time becoming heated, mounts upwards before it has received its full load of moisture, and is succeeded by another, to be, in its turn, heated and charged with vapour.

As soon as the ascending stratum of air has gained a higher and colder region, it becomes cooled down also, and in this state, having less capacit for moisture, it deposits the greater part of its watery particles in the form of extremely minute globules or spheres. These constitute clouds, which are of various aspects, according to their height and the density of their vapour particles.

The highest and lightest cloud is called *Cirrus*, and is caused by a slight deposition of vapour pretty high in the atmosphere. It is in form a light elongated white streak, sometimes curled up at the extremity, and thus termed *Maré's Tail.*

The next cloud is the *Cumulus*, a roundish and denser mass or series of masses scattered along the heavens.

The third is the *Stratus*, or mist cloud, floating along the tops of mountains, or rolling along the surface of the plains.

These are the three primary forms, but there are several combinations of them, such as:—

The *Cirro-Cumulus*, a combination of the cirrus and cumulus.

The *Cirro-Stratus*, a combination of the cirrus and stratus, often scattered in beautifully coloured groups over the evening sky, and likened to the variegated back of the mackerel.

The *Cumolo-Stratus*, in large masses, and piled up with their white edges to the sun, like rocks and castles; often stationary, or slowly moving contrary to the lower currents of air.

The *Cirro-Cumulo-Stratus*, a mixture of all the three, forming the *Nimbus*, or dense blue mass, formed low down in the atmosphere, and from which rain proceeds.

The various forms of clouds are thus arranged in the atmosphere according to the greater or less degree of moisture which the air contains; the higher and lighter form indicating generally the least quantity of moisture, but all contributing by their varied shapes and incessant changes to the beauty and grandeur of the aerial canopy of heaven.

The azure blue of the sky depends upon the minute portions of vapour which the atmosphere contains. Air itself, when pure, is perfectly colourless, even when viewed through a large mass, as may be proved by looking at a distant snowy mountain, which still retains its pure whiteness unimpaired. This would not be the case, were the medium through which it is viewed of any particular colour.

The minute particles of vapour continually present in the lower atmosphere, reflect back to the eye the blue rays of light, while all the other rays are dispersed. On elevated mountains, the heavens appear of a deep blue approaching to black, because there is little or no vapour so high as to cause reflection.

Were there no vapour, there would be no reflected light in the sky; and thus, even in day-light, the dome of the heavens would appear as dark as midnight, except when the eye was turned directly to the sun. Denser clouds, again, reflect white light, as is seen in the beautiful sunlit edges of floating cumuli; or clouds not unfrequently refract the rays of light passing through them, and thus we have the splendid tints of evening and morning clouds.

The rainbow is another splendid optical appearance in the sky, and occurs during a sun-shiney shower. It is caused by the rain-drops refracting the rays of light, and separating each ray into its primary colours.

Though the process of evaporation is continually going on, and there is always more or less moisture in the air, yet rain or fogs are only of occasional occurrence.

The tendency of heated air to mount upwards, and to do so before it has been fully charged with moisture, has the effect of keeping the lower atmosphere, for the most part, pure and transparent, both on land and sea.

The current of heated and moist air may continue to flow onwards in one direction for hundreds and thousands of miles, or it may deposit part of its moisture in the higher regions, forming thin fleecy clouds; these clouds may sink down into a lower and warmer stratum, and be again dissolved and become invisible, and thus a series of changes may take place in the upper atmosphere without influencing the lower.

To produce rain, it is necessary that two currents of air, unequally heated and unequally moist, should meet together. When a hot-moist and a cold-dry current thus meet, the mixture of air resulting cannot contain all the moisture which existed in the hot current, and consequently the overplus falls down to the earth.

At first a dense vapoury mist is formed, the minute particles of this mist join and accumulate into larger masses, and before the moisture has fallen to the ground, it has assumed the round form of a sphere or rain-drop; obeying the laws which all matter, and especially fluids, are subject to,—the laws of gravity and cohesive attraction.

Exemplified in melted lead, poured from shot-towers, forming, in its descent, lead-drops.

In some regions of the earth, rain rarely or never falls. This is the case in Lower Egypt, in the central portion of the African continent, or Great Sahara, in Tibet, and on the west coast of Peru in South America.

This arises from local causes, chiefly from high and extensive mountain ranges intercepting the air currents, and causing a deposition of their moisture; and also from the uniformity of elevation of the air current, and the absence of all opposing currents of lower temperature.

Extensive mountain ranges modify the fall of rain, not only from their positions influencing the direction of the currents, but from their cold summits acting as condensing agents; and also exercising electric influences, to be afterwards mentioned.

More rain falls on mountain ridges, and even on each side of the line of their direction, than in valleys and plains unconnected with such elevations.

Rain-drops increase in size and number as they descend to the earth.

The pastoral regions of the west of England and Scotland derive their character, as distinguished from the grain-bearing valleys of the eastern districts, as much from the quantity of rain which falls on them, as from their elevated form and the nature of their soils.

Uncultivated countries, covered with dense forests, are more subject to rain than cleared and cultivated, and especially well drained soils. The agricultural improvements of Britain are yearly adding to the mildness of its climate.

In dry parched regions, on the other hand, the country may be rendered almost barren by cutting down its trees and brush-wood; thus exposing the soil to the too great influence of the sun.

The mean quantity of rain which falls may be measured by a rain gauge, and the quantity indicated in inches. The Hygrometer measures the amount of moisture in the air. (See Appendix, No. IV. and Table VI.)

As evaporation is greatest within the tropics, so most rain falls there.

In the torrid zone, in some localities from 115 to 200 and 300 inches fall annually; the mean yearly quantity which falls is about 95½ inches, or nearly 8 feet perpendicular height. In the temperate zones 35 inches. In the frigid zones, even including snow, from 10 to 15 inches.

Within the range of the tropics rains are periodical and come with the change of the monsoons. The "early rains" of Palestine begin in October, and the "latter rains" end in March.

Though most rain falls in the tropics, yet it falls only occasionally and suddenly, so that there are much fewer rainy days there than in the temperate regions. In some localities there is almost a daily drizzle without much rain actually falling.

This is the case in the West of Ireland, the Hebrides, and the Falkland Islands.

The mean annual depth of rain which falls on the whole earth, is estimated at 60 inches or 5 feet; equal to seven hundred and sixty billions of tons.

The ocean is the primary source of all the earth's moisture. The surplus moisture which is not taken up by plants and animals, is returned into the ocean by rivers, or deposited in lakes, and, temporarily, in cavities and fissures of the soil, to issue out as springs; or is stored up as glaciers in winter, to be gradually thawed in summer.

As the equatorial air-currents are the means of diffusing heat from the equator to the poles, so also do they carry along and diffuse moisture; and thus, part of the excessive evaporation of the torrid zone is carried to the less evaporating surfaces of the temperate and frigid regions, so that the hot vapour of the equator may in its turn become the glacier of the poles.

In the processes of evaporation and rain, a continued circle of operations is carried on, affording an admirable example of the harmonious adaptations of the scheme of nature. For, were this circle interrupted, the destruction of animal and vegetable life would be the consequence, and the world would be speedily converted into a lone and barren desert.

With all its apparent irregularity, too, the fall of rain is found to be on the whole very uniform, taking a series of years as an average.

In our northern hemisphere, the W. and S.W. winds bring warmth and moisture, the N. and E. winds bring a cold and dry air; hence, most rain falls on our western and south-western coasts, and least on the eastern.

SECTION VI.—SNOW, HAIL, DEW.

In winter, when the air is at the freezing point, instead of a fall of rain, the particles of moisture are congealed into a flake of snow, and thus descend to the earth.

Snow, then, is vapour congealed before its minute globules had time to join together to form a rain-drop.

A flake of snow, when minutely examined, thus affords a specimen of the kind of particles of which clouds are composed. These particles will be found to be minute solid spheres of water, and not hollow vesicles, as was at one time supposed.

Immediately before and during a snow-storm, the air near the earth's surface becomes milder, and the thermometer rises, because vapour, in assuming the solid form of snow, gives out a portion of its heat.

The reverse is the case during a thaw. Then, the air becomes chiller, because melting snow greedily absorbs the surrounding heat.

In the northern parts of the continents of America and Asia snow lies deep from November till the end of April. In Britain, snow rarely lies more than two or three weeks at a time.

In the northern hemisphere the limit of the fall of snow is lat. 30°, in the southern hemisphere the limit is lat. 48°.

Sometimes rain-drops are formed in the upper portions of the atmosphere, and in their descent fall through a stratum of air at the freezing-point, when the rain-drop assumes the form of hail.

A sudden and partial congelation of currents of the atmosphere may happen even in summer, and thus hail-showers frequently occur at this season.

Hailstones of a large size, and even pieces of ice of an inch or more in diameter, sometimes fall in summer and autumn, and do great damage to corn-fields and vineyards.

Hail and snow, crystallized into various circular figures of six and eight sides, sometimes fall from the atmosphere in this country, especially in severe winters; and frequently in more northerly climates.

A MIST or fog is a deposition of vapour from the air so near the surface that the particles have not had time to coalesce so as to form a rain-drop. Mists often form on the tops of mountains, because these mountain-tops being colder than the air-current passing over them, the moisture is condensed. This condensing process may go on for many hours, and thus the mist-cap will appear to be stationary.

Near high table lands warm air is frequently carried up in a current along their sides to the cold summit, where its moisture is condensed; and this cloud, again falling into warm air beyond the influence of the mountain, is redissolved and disappears.

A cloud of this kind frequently surrounds the summit of Table Mountain, Cape of Good Hope; and is often seen on the cold mountain-tops of Scotland.

If the lowest stratum of air had not a tendency to mount upwards on its becoming heated and charged with moisture, there would prevail at the earth's surface a continual fog or deposition of vapour; but instead of this the heated air mounts aloft, and carries its vapour in currents, or in floating clouds of various forms, all over the sky.

DEW is a deposition of moisture caused in a somewhat similar manner as mist. After sunset, when the sky is clear and unclouded, the surface of the earth immediately commences to radiate back into space the heat which it had absorbed during sunshine. This radiation is greatest from all pointed vegetable substances, or woolly or hairy bodies; so that these points, being cooled down sooner than the general surface of the soil, condense the moisture of the air which collects on the summits of blades of corn, and grass, and leaflets, in the form of pearly drops of dew.

Dews are of inestimable value in climates where rain seldom falls, and in other countries, especially in spring, when the tender herbs and leaflets of the springing corn most require the aid of gentle and partial moisture.

Dew is deposited only in clear cloudless nights, because clouds radiate back heat to the earth, and thus prevent a low degree of temperature. Any slight matting or netting will thus protect fruit blossoms during frosty nights by preventing radiation. The human body exposed to night air radiates or parts with its heat quickly, and this is the cause of disease; and vulgarly the night *dews* are blamed instead of the night *cold.*

HOAR FROST is a deposition of dew, afterwards congealed or frozen, and formed into beautiful crystals.

Halos are those luminous rings, variously coloured, seen around the sun, or more commonly the moon, in winter, and during frost, or especially previous to a fall of snow. These circles are caused by clouds of icy crystals refracting or separating the rays of light into their different colours.

SECTION VII.—ELECTRICITY OF THE ATMOSPHERE. MAGNETIC CURRENTS.

Electricity or the electric influence pervades all matter on the earth's surface.

It is something of the same subtile nature as light, heat, and magnetism; and, though universally diffused, and most probably acting as an important agent in nature, is seldom very conspicuous.

It appears to be diffused over the surface of bodies, and exists in proportion to the superficial extent, not to the absolute weight. Yet it is imperceptible to the senses, except when its equilibrium is disturbed. It then becomes visible when passing from one body to another.

Heat and friction, as well as chemical and organic changes, disturb its equilibrium.

A glass rod, or piece of sealing-wax or amber, heated and rubbed, exhibits electric properties. When thus rubbed, it will attract to it small bits of paper or thin slices of pith, which, after coming into contact with the rod, will be again repelled.

Bodies may be in two states of electricity, when they are said to be *positively* or *negatively* electrified.

Some bodies readily transmit electricity—as metals, earthy matters, water, and vapour, growing plants, and the bodies of animals. Other substances are non-conductors,—as glass, wax, amber, and silk.

There are three natural processes which tend to excite the electric action in the atmosphere: The application of heat, and consequent evaporation of water; the friction of winds; and the process of vegetation in plants.

The earth's surface is generally in a negatively electric state; the atmosphere, especially when dry and serene, is positively electric; and hence between these two there is an almost perpetual interchange of electric phenomena.

Thus when a minute particle of water exists as a portion of the fluid mass of the ocean, it is accompanied by a corresponding minute degree of electricity in proportion to its surface; but when this particle expands into a large mass of elastic vapour, it takes with it in its upward ascent into the air a corresponding charge of electricity. In this way electricity is daily taken up into the atmosphere; but on the condensation and descent of the vapour, the excess of electricity is liberated, and may accumulate in the higher regions of the atmosphere, or descend again to the earth.

Dry air is a bad conductor of electricity, but moist air readily and silently conducts it to the earth, just as a wire or chain conducts artificial electricity to the ground.

On the fall of rain or snow, electricity is always evolved, or during the condensation of mists, or the deposition of dew.

The quantity of electricity is greater in the atmosphere during the day than in the night; it is greater in dry and serene winter weather, and less in summer; yet electric disturbances are much more frequent in warm than in cold weather, and in tropical than in temperate or polar regions.

Thunder-storms are also more frequent in elevated situations, as in the range of the Andes and other high mountains; and they accompany the periodical changes of the monsoons.

The tropical current of air (warm and moist) is *positively* electric; the polar current (cold and dry) is *negatively* electric.

When these two currents meet there is an interchange of electricity. If the air be uniformly moist, the interchange takes place silently and unseen; if, on the contrary, the surrounding atmosphere be warm and dry, the electric current becomes visible as lightning, accompanied by thunder.

Thunder-storms occur during calm, hot and sultry weather, or during high gales and hurricanes. They are frequent at all seasons in the tropics, common in summer in temperate regions, and rare in winter, and very rare at any season in the polar zones.

An explanation of these propositions will be found in the preceding statements. They depend upon the more or less vertical position of the sun, and the unequal distribution of heat.

Thunder-storms in this country generally come from S.W. and W. A large dark cloud suddenly forms in these directions, the upper edge rounded and well-defined, the under edge ragged and spongy. Numerous smaller *accessory* clouds may also be seen forming at a little distance, and rapidly rushing to join the main cloud. Sometimes the cloud and the air around is of a lurid red hue.

When this cloud, fully charged with electric matter, approaches nearly to contact with the non-electric current or cloud, a discharge of lightening passes from one cloud to the other, the concussion of the air producing a sound; and this sound is reverberated and prolonged by the earth and atmosphere, producing the rolling noise of thunder.

Sound travels at the rate of 1,120 feet in a second, or nearly a mile in four seconds of time, and thus, by counting from the appearance of the flash, which is instantaneous, till the sound is first heard, the distance of the thunder may be ascertained.

Instead of passing from one cloud to another, the lightning may pass from the thunder-cloud to the earth; or, a negative cloud hanging over a particular part of the earth may render the earth positive (by what is called *induction*). In this latter case the electric matter ascends. Or the discharge downwards suddenly taking place at one end of a long cloud, an upward discharge occurs from the earth to the other end, causing what is called the returning-stroke.

Metals, houses, trees, and animals, being ready conductors of electricity, if any of these are in the line of the descending fluid they are instantly destroyed. In the ascending stroke of lightning, brick houses have been carried up into the air, and the *pollen* of plants or spawn of fishes, and young frogs, have been carried up and transported to a considerable distance.

Metallic rods of iron or copper, as being the readiest conductors of electricity, are attached to houses and ships, with a point projecting upwards; and, if the electric fluid comes near, it passes harmlessly along the rods into the ground.

The force of a thunderbolt is sufficient to destroy the largest trees, to split rocks and level large buildings; and, when it passes to the earth, through silicious sand, it often melts the sand into a long rod of glass called a *fulgorite*.

Sheet lightning occurs when the electric matter is much diffused, and at a considerable height; forked lightning or thunderbolts when the fluid is more concentrated and nearer the earth.

The sound of thunder is not heard generally beyond 6 or 10 miles; when a thunder-storm occurs higher up in the atmosphere no sound is heard.

Heavy rain almost always accompanies or follows thunderstorms; sometimes hail showers, and the fall of pieces of ice.

Loud thunder sometimes occurs in South Africa without any appearance of clouds.

Thunder-storms refresh and generally cool the air. The electric condition of the air has a peculiar effect on the lower animals, and even on man. This is exemplified in the rapid motion of leeches in water, in the agitation of wild fowl, and the restlessness of cattle. For an admirable poetic description of a thunder storm, see Thomson's Seasons (*Summer*), and Virgil's *Georgics*.

The AURORA BOREALIS, or northern light, is supposed to be of electric origin, and seems also to have an intimate connection with the magnetic currents. This appearance is most frequent during autumn and winter,—is very common and extremely brilliant in the polar zones,—is of frequent occurrence also in the temperate regions, but is never seen within the tropics.

The Aurora consists, in its simplest state, of masses of glowing light in the northern and western horizon, sometimes stationary, and at other times radiating innumerable pencils of brilliant beams. Or a large arch is seen either spanning the heavens somewhat like a rainbow, of a pale white colour, in a direction from N.W. to S.E., that is, crossing directly the magnetic poles. Pencils of rays rapidly shoot from the north towards this bow in successive and rapid discharges. The bow is sometimes stationary, or it has a progress from N. towards the zenith. Sometimes it diverges into a waving or radiating coronal all over the heavens; and, after a time, the whole luminousness disappears.

The height of the Aurora is as yet unascertained. Conjectures, and even attempted calculations, state it variously from 5, 10, 20, to 100 miles from the earth's surface.

It is supposed to be caused by electric matter either in regions beyond the earth's influence, or of electricity accomplishing an equilibrium of its condition within the range of the earth's atmosphere.

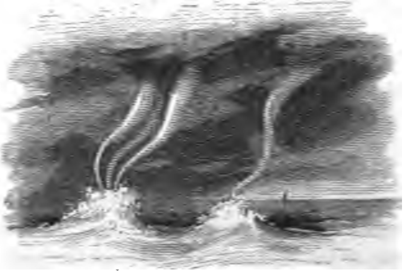
HURRICANES are supposed to owe their origin chiefly to electric agency, especially those circular hurricanes so common in tropical climates, and which blow round a centre, which centre is in progressive motion.

Hurricanes are very prevalent among the West India islands, Barbados especially, where a most destructive one occurred in 1831. They are common too on the shores of the Indian Peninsula, in the Indian Archipelago, and in most tropical situations at the change of the monsoons.

TYPHOONS, TORNADOS, and WATER-SPOUTS, are also caused by electric agency.

Tornados occur on land, and consist of a spiral column of air rapidly revolving and passing along the surface of the ground, frequently tearing up and carrying along with it trees, cottage roofs, hay ricks, and other substances.

WATER-SPOUTS occur at sea, and consist of spiral tubes of air, of a conical form, with the broad end generally uppermost, and proceeding from a dense rain-cloud. The condensed



Water Spouts.

vapour of the cloud descends in these spiral tubes, and by the lower ends water ascends from the sea or fresh-water lakes, and is carried along for many miles, till the electricity, having found an equilibrium, they are dispersed, and the water falls in a torrent. Sometimes one, two, or three of these water-spouts are seen together.

A black spot in the distant horizon moving rapidly along, and suddenly enlarging, gives the first indication of a water-spout.

Meteors, or **Shooting Stars**, are balls of luminous matter, which are often seen moving rapidly through the heavens, and apparently falling from the higher regions towards the earth.

In clear autumnal evenings, especially from August to November, the spectator can never fail to witness many of them. Sometimes hundreds occur in the course of an hour.

These are supposed either to be electric accumulations formed during the day, and descending in balls or masses after sunset; or they are bodies beyond the range of the atmosphere, and moving in space. Or perhaps the numerous meteoric appearances so frequently seen consist of both these, and are thus of two kinds.

Occasionally large meteoric bodies pass through the atmosphere, which are certainly not electric, but composed of solid matter. These have fallen repeatedly on the earth, and are called *aerolites*.

In the year 1783 a remarkably large meteor passed over Britain and part of Europe. Its size was calculated at half a mile in diameter, its elevation 50 miles, and its velocity 20 miles in a second. During its course it burst into fragments.

A, circular form of the meteor; B, its oblong appearance previous to bursting into fragments, as at C.

Aerolites have fallen in various parts of the world, in Europe, in India, and in America. Their composition is generally much the same, and consists of magnetic iron, nickel, sulphur, and small quantities of silex and other earths.

The largest known aerolite, 7 feet in length, fell in Brazil.

MAGNETIC CURRENTS also prevail on the earth, as indicated by the magnet.

(See Appendix IV).

There are two magnetic poles; one near the N., and the other near the S. pole, to which the magnetic needle points.

The N. magnetic pole is in lat. 70° N., and lon. 97° W.; the S. magnetic pole is in lat. 75° 5′ S., and lon. 154° 8′ E.

At the equator the needle is horizontal, but on approaching to either pole, one point dips gradually downwards, till at last the needle stands perpendicular.

The direction of the magnetic needle is liable to great variations, in different places, often from local causes, and also at different times of the day and night. There are also certain places where the magnetic influence is more intense than at others.

In the northern hemisphere, one of these places is in North America, S.W. Hudson's Bay, the other is in Siberia.

SECTION VIII.—THE OCEAN.

The surface of the globe has an irregular form of deep valleys and elevated mountain ridges; and the water of the ocean, obeying the law of fluids, occupies all the lower portions of this surface, so that the higher parts only of the earth, rising above a general level, form continents and islands.

The ocean covers somewhat more than two-thirds of the earth's surface, and forms a continuous fluid around the globe, with a mean level surface.

This immense zone of water, equal to 144,463,427 square miles, is usually divided into the Pacific, the Atlantic, Polar, and the Indian Oceans. Inland seas are portions of the ocean enclosed by land.

The depths of the ocean vary as the land does in its hills and valleys, but perhaps in greater extremes.

The highest mountains are about 5½ miles (28,000 feet) above the mean level, whereas the mean height of the whole continents, were the higher parts levelled down to an uniform plane, would only be from 900 to 1,000 feet.

Were the whole existing dry land submerged in the ocean, it would only raise its present level about 300 feet.

Soundings in the ocean have been made in the Atlantic to the depth of 27,000 feet without finding a bottom; and, as the Pacific Ocean also appears to be in many parts very deep, it is probable that the mean depth of the ocean corresponds in some degree with the mean height of the land.

Large portions of the ocean, however, are not above 100 to 500 feet in depth, especially along the shores of continents and islands, or where there are extensive sand banks, such as at Newfoundland, and where lagoons and reefs abound.

The surface of the Pacific Ocean nearly equals in extent all the dry land on the globe.

The expanse of ocean greatly predominates in the southern hemisphere. The torrid zone is chiefly occupied by the ocean. The proportion of land to water in the northern hemisphere is as 2 to 3; the proportion in the southern hemisphere, exclusive of the antarctic zone, is nearly as 1 to 6.

At the depth of a mile and a quarter the pressure is calculated to amount to 2,809 pounds on a square inch.

As water is greatly heavier than air, the pressure of a depth of 5 miles of water must be prodigious.

Sea or salt water is one-third heavier than fresh water. Sea water freezes at 28½°, fresh water at 32° of the thermometer.

Sea water contains about three per cent. of salts; and this quantity varies little throughout all its extent.

The ocean is said to be somewhat more salt at the equator, from the excessive evaporation, and less so at the poles, from the melting of the polar ice. The saline ingredients are in the following proportions in 1000 parts of water :—

Chloride of sodium (common salt),	22·	parts
Sulphate of sodium, . . .	4:	...
Chloride of magnesium, . .	4:3	...
Chloride of calcium (lime) .	1:	...

Pure sea water is perfectly transparent; vegetable and animal matters impart to it a greenish and yellowish hue, but its universal colour is that of blue, its particles reflecting the blue rays of light like the atmosphere. Shallow seas near land have a greenish hue, partly from marine vegetables containing *bromine* and *iodine*, and partly from the nature of the bottom. In the Red Sea there is found a minute red vegetable and red coloured corals. The Yellow Sea is tinged with yellow mud.

The variegated cloudy sky and partial breezes, as well as the depths and shallows of the bottom, often impart a pleasing light and shade over the surface of the ocean; while, far out at sea, the deep blue of its surface universally prevails.

A certain portion of atmospheric air is mingled with water; and as vapours are continually passing up into the air, the ocean and atmosphere, as they press upon each other, also to some extent intermix.

The ocean, like the atmosphere, is incessantly in motion; and the same causes excite motion in each. These causes are,—the sun's heat, the daily revolution of the earth, and, in the case of the ocean particularly, the conjoint attraction of sun and moon.

The tides are caused by the attraction, chiefly of the moon. That part of the ocean that is directly opposite the moon is raised up into a wave, and, as the motion of the earth is continually changing the relative position of the ocean surface with respect to the moon, the tidal wave rises in succession as the earth revolves.

As, from the revolution of the earth, every place comes under the influence of the moon twice in the 24 hours,—once directly under the moon, and again at a point on the opposite side of the globe,—there are thus two changes of the tide within this period.

The tides vary greatly in different places, and from various causes,—as depth of sea, interference of land, the meeting of two tides. They also vary periodically with the position of the moon as to new and full. On the S.W. shores of Britain the spring tides rise to 50 feet,—in the Atlantic generally to 12 feet,—at St Helena their greatest rise is only 3 feet,—while at Tahiti, in the Pacific Ocean, they are scarcely perceptible.

The friction of winds causes waves and currents, which, independent of the tidal waves, produce great commotions on the surface of the ocean.

The highest waves do not exceed 40 feet even in storms, —their general height is from 10 to 20 feet. The surface of the ocean is only thus agitated, the deeper parts remaining tranquil even in the greatest storms.

The ocean receives its temperature entirely from the sun's rays. Like the air, water transmits heat and light, but the absorption of heat by water is much greater than by air.

The ocean, unlike the air, is heated from above downwards, and, as water is a bad conductor of heat, this process is slow; but the sea retains its heat longer than the air or even the earth, as it does not readily radiate heat from its surface.

There is in the ocean nearly the same distinction of zones of temperature as in the earth.

For 10° on each side of the equator, the mean surface temperature is 80° of the thermometer. At lat. 56° 26′, both N. and S. the temperature is 39°.5 at the surface. Beyond these two points, towards each pole, the temperature of the ocean surface decreases to the freezing point, and below it. Thus forming a torrid, two temperate, and two frigid zones.

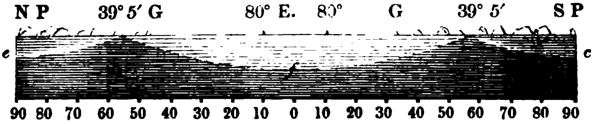
In the torrid and temperate zones, the heat of the sea diminishes from above downwards.

In the frigid zones, the temperature increases from the surface downwards.

A deep lake of fresh water does not begin to freeze till the whole is cooled down to 39°. Salt water freezes if its surface only be cooled down to 28°.5.

The water of the Gulf-stream, and other currents, by passing along the shores of tropical lands, attains a temperature of 84°.

There is a waving line throughout the ocean, indicating a uniform temperature of 39° 5′, and this also is the mean heat of the ocean.



E is the equatorial zone of the ocean, with a temperate region on each side; N P S P are the polar zones; *e f c* the line of equal medium temperature. At the equator, this line is at the depth of 7,200 feet. From this point the line rises on each side to the latitude of 52° 6′, where it reaches the surface of the sea. Beyond this point, towards each pole, the line again gradually sinks, till at 70° of latitude it is found at the depth of 4,500 feet. G G the limits at which floating icebergs are usually found.

The unequal heating of the surface of the ocean causes currents in it somewhat like those of the trade-currents of the atmosphere.

Cold water being considerably heavier than heated water, there is a continual pressure and flow of cold water from the poles to the equator, which displaces the lighter water there, and causes a warm current to flow from the equator towards the poles.

This ocean current would flow due N. and S. from the equator like the trade-winds, if it were not deflected from its course by the earth's daily motion, and by the obstructions of continents.

In the northern hemisphere, a great oceanic current flows in the Atlantic from the equator north-westward.

One branch, called the *Gulf Stream*, flows northward through the middle of the Atlantic, till it reaches the Cape de Verd Islands. It there turns west, passes the Caribbean Sea and the strait between Cuba and Yucatan, winds round the Gulf of Mexico, and rushes out by the Bahama Channel—then, spreading to a great breadth, it sweeps along the shores of North America to Newfoundland. At this point it meets with a northerly current coming from Baffin Bay, and both bend southward, passing the Azores and Canary Islands, and thus return by the west coast of Africa again to the tropics.

A branch of this current proceeds from Newfoundland north-eastward to the British shores, and often carries along and deposits tropical seeds and plants on the shores of Scotland and Norway. The speed of this great current varies from 1 to 5 miles an hour. Its temperature at the surface is from 70° to 84°, and it performs its circuit of 3,800 leagues in about 34 months.

Another branch of this tropical current deflects along the coast of Brazil, and passes southward through the Strait of Magellan.

In the Pacific Ocean, a similar current prevails from the western shores of South America, flowing N.W. till it reaches the Indian Ocean.

A current sweeps along the Bay of Bengal, and, passing onwards, skirts the African shores, and doubles the Cape of Good Hope.

In the Pacific, also, two great polar drift currents set in—one flowing from the south pole, towards the west coasts of South America, and the other from Behring Sea, in the Arctic regions, flowing southward.

These ocean currents from the tropics, having a high temperature, flow towards the colder parts of the earth, and thus tend to diffuse heat over its surface. Thus it is that islands, surrounded by a warm sea, have a higher temperature in winter than inland places far removed from such influence.

In summer, the accumulated ice of the polar regions is thawed, the immense masses are broken up, and innumerable icebergs are floated towards the equator, and, gradually thawing, thus tend to mitigate the tropical heat.

In the northern hemisphere, icebergs are met with to the latitude of 46° N. In the southern hemisphere icebergs float as far as 36° S. These icebergs float along in immense numbers, and many of them are from 1 to 5 miles in diameter, with a thickness of 200 to 300 feet. They often transport large rocks, trunks of trees, and portions of soil embedded in their masses.

The ocean currents thus combine with those of the atmosphere to diffuse a more equable temperature over the globe—they also prevent the stagnation and local accumulation of impurities in the sea, and serve important purposes in navigation, and the diffusion of plants and animals over the earth.

The ocean, like the earth and air, teems with organic life; having, however, both vegetable and animal forms peculiar to itself.

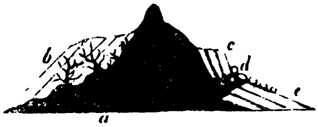
These are arranged according to zones of depth; the shallow seas and shores, which enjoy most of the solar heat and light, being more largely furnished with living beings than the ocean depths, which are comparatively dark, chill, and untenanted.

Marine vegetables are of a simple structure, generally without flowers, and are divided into *fuci* and *confervæ*. Sea-tangle or *laminaria*, and bladder-ware or *kelp*, gulf-weed or *sargassum*, grow abundantly in the ocean. Sponges, corals, medusæ, and immense numbers of animalcules that emit a phosphorescent light, shell animals, fishes, seals and whales, are the most remarkable classes of its animal inhabitants.

SECTION IX.—CONTINENTS AND ISLANDS.

Those portions of the earth's surface that rise above the mean level of the ocean, are called Continents and Islands.

These elevations have taken place at different intervals of time. Mountains have been raised up by the action of heat from below, and generally consist of *igneous* rocks, divided into *granites*, *greenstones*, and *lavas;* and the plains and acclivities of mountain ridges are formed of *sedimentary stratified rocks*, as slates, limestones, and sandstones, that have originally been formed at the bottom of the sea.



This diagram exhibits the general structure of a mountain. The centre (*a*) is a mass of igneous rock, which has been protruded from below in a melted state, and the materials have afterwards crystallized. The sides are composed of various sedimentary strata (*b c e*), which, originally deposited as sand in the bottom of the sea, have become consolidated and raised up by the igneous rocks. The older mountains are generally formed of *granite;* the secondary of *porphyry*, *greenstone* and *basalt;* the newer of *lava*.—(Appendix, No. VIII.)

The dry land, therefore, has not always had the same boundaries, or elevation, or shape, as at present, but successive changes have modified the surface.

The oldest formed granitic mountains are not the most elevated; on the contrary, the newer or *tertiary strata* are found highly elevated on the Alps, the Himalaya, and the Andes.

On viewing the distribution of land and water on the globe, it is to be observed, that nearly one-third part of the earth's surface is dry land, and two-thirds ocean (or 13 to 36).

The whole amount of dry land on the earth has been estimated at 52,353,231 English square miles. Of these, in round numbers,

Europe contains . . .	3 millions.
Asia, ...	17 ...
Africa, ...	12 ...
America, ...	18 ...
Australasia, . . .	2 ...

In this and the relative populations afterwards stated, only an approximation to the real facts is attempted to be given; and the statements usually made in books vary greatly.

The relative proportions of land and sea are according to the calculations of the late Professor Rigaud of Cambridge.

The greater proportion of land is placed in the northern hemisphere. The whole of Europe and Asia, with their islands, lie north of the equator, more than two-thirds of Africa, and about two-thirds of America.

All the great leading terminations of continents, extend in headlands and promontories to the south; and the great breaks, or indentations of land, open in this direction also.

Islands lie generally in clusters or chains, and the prevailing direction of these chains is S. and N., as the British Islands, the Philippine Islands, the Kurile Islands.

Land has generally sea forming its direct opposite on the other side of the globe (or its antipodes). There is only one-twenty-seventh part of land which has land directly opposite to it.

The summits of the highest mountains are from 3 to 5½ miles above the level of the sea. The mean height of the three continents of Europe, Asia and America, is about 1,000 feet above the sea level.

Thus, if all the mountains in Europe were levelled into the hollows and plains, a uniform surface of 671 feet in height would be formed. If the whole of Asia were levelled in the same way, it would stand at 1,132 feet above the sea; North America would afford an average of 748 feet; South America, 1,152 feet.

In a few cases, there are valleys depressed considerably below the level of the sea. The valley of the Dead Sea is depressed 1,311 feet—that of the Caucasus, 83½ feet.

Plains and table-lands are those portions of country more or less elevated, but with a level surface. Valleys are hollowed out portions between, or intersecting, mountain ridges.

The greater proportion of habitable valleys and plains, lie not more than 100 to 500 feet above the sea—more rarely from 1,000 to 10,000 feet.

Had the dry land been one uniform plane surface, the rain water would have stagnated, forming a continuous morass; but the mountain elevations and valleys permit of drainage in all directions, and are so many conduits for collecting rain water, storing up the snows of glaciers, and for originating rivers and directing their courses.

In the existing distribution of land and water on the earth, it is farther to be remarked, that the greatest proportion of land is in the north temperate zone, there being thirteen times as much land in the north temperate, as in the south temperate zone. The highest mountains in the world are on the boundary of the tropics, the Himalaya is on the north; and Aconcagua is the highest summit of the Andes on the south. A small proportion only of land is placed within the tropical zone. The continent of Africa forms the largest portion, and America the next, while the tropics in the Pacific are studded with minute islands, which bear a small relative proportion to the surrounding ocean. Had it been otherwise—had the length of the continents stretched along the equatorial region instead of crossing it—a great increase of heat on the whole earth would have been the consequence. An excess of land toward the polar circles, and especially of elevated land, would have had the contrary effect of greatly diminishing the general heat of the globe.

There is reason to believe that high land exists within the antarctic circle.

SECTION X.—DISTRIBUTION OF MOUNTAINS.

Mountains are distributed in chains or ranges, grouped together, and rarely single.

The term mountain is applied to elevations which exceed 1,000 or 2,000 feet in height; they are called hills when under this height. Hills may sometimes appear single and detached, though they in reality belong to some great range in the vicinity.

Mountain ranges may either intersect continents or islands, thus forming the central high ground, as the Alps in Europe, the Grampians in Scotland; or they may run along one or both maritime edges of a country, as the Andes of South America, the Ghauts of Hindostan.

The highest mountain range in the world, as yet ascertained, is the Himalaya mountains of Asia. Kunchinginga is 28,178 feet, or 5⅓ miles. The next highest range is that of the Andes, which traverses South America from N. to S.—Sorata and Aconcagua rising to nearly 24,000 feet.

These elevations are about 70 times the height of St Paul's, London; 50 times the height of the largest Pyramid of Egypt; 30 times the height of Arthur Seat, Edinburgh; and, to ascend to the summits, would form a distance equal in length to that of walking from one end of London to the other. Height of St Paul's, 404 feet; Pyramid of Egypt, 479 feet; Arthur Seat, 822 feet; diameter of London, 7 miles.

A succession of mountain chains and table-lands traverse the continents of Europe and Asia in a direction from N.W. to S.E., and between the parallels of 30° and 45° N. latitude.

Beginning at the W., these mountain chains consist of the Alps, the Pyrenees, the Apennines, the Carpathian, the Taurian, Caucasian, Hindoo-coosh, Himalayan, Tibetan, Mongolian, Northern Chinese. The Scandinavian mountains form the N.W. boundary of Europe.

North of the Alps and the Black Sea, extend the great Russian and Siberian plains. These are separated in the centre by the Ural mountains, which extend from N. to S.; and the high table-land of north eastern Asia is intersected by the Altai mountains, and bounded on the N.E. by the Aldan and Manchoorian chains.

The Iranian mountains extend southwards along the N.

side of the Persian Gulf; and the Ghauts bound both maritime edges of the Indian Peninsula.

In the continent of Africa, an elevated mountain chain runs along its N.W. border, and the Abyssinian Alps are situated on the north-eastern side. The Mountains of the Moon are supposed to form the centre of an elevated tableland in the interior of Africa. The southern portions of this continent, so far as explored, are comparatively level—a table-land forming the southern extremity.

The mountain chains of America, like that continent itself, extend in a direction from N. to S.

In North America, on the W., the Rocky mountains extend from the borders of the Arctic Sea to the table-land of Mexico. On the E., the Alleghanies extend from the mouth of the St Lawrence river to the southern territories of the United States.

The northern portion of Mexico consists of a high tableland, which terminates towards the S. in a series of elevated volcanic mountains; and the same elevated chain extends through central America.

The Andes extend along the whole western coast of South America; the southern portion, the Patagonian and Chilian Andes, consists of a single chain of mountains.

In Bolivia they separate into two *Cordilleras*, or chains—an inland and coast chain. The highest part of the Andes is near the centre, in Bolivia; Sorata, Illimani, Aconcagua, being the culminating points.

The Peruvian Andes form three chains. The Andes of Quito at first form only two chains, but again branch out, and terminate in three.

A series of lesser mountain-ranges traverse Brazil from N. to S.

The Parima mountains, New Granada, run from E. to W.

TABLE-LANDS or PLATEAUX are next in altitude to the mountain-ranges, and generally connected with them.

These are elevations of the earth's surface, rising to 1,000, 10,000, and even 15,000 feet above the ordinary level; extending over a considerable space, and with flat plains on the top, forming fertile lands and places of human habitation.

The principal elevations of this kind are the great table-land of Tibet and of Gobi, in central Asia; the table-land of Abyssinia, in North Africa; the table-lands of Mexico and of the Andes, in South America. In Europe, the centre of the Spanish Peninsula forms the most remarkable table-land.

The great plains and valleys are those of Russia in Europe, and Siberia in Asia ; the valley of the Caucasus, depressed 83½ feet below the level of the sea; the valleys of the Euphrates and Ganges; the great plain of China; the Arabian and African deserts.

In North America, is the great central valley of the Mississippi; in S. America, the valleys of the Orinoco and Amazon, and the vast plains of the Pampas and Patagonia.

Australia is in general a level country, not greatly elevated above the surface of the sea, and with few great chains of lofty mountains.

Valleys and plains are a natural consequence of the elevation of mountains. Wherever there are great elevations of the surface, there will be found corresponding depressions.

Sometimes valleys are deeply hollowed out and depressed in the middle, in other places they are filled up and smoothed over with clay, stones, loose earth, and sand, called *diluvium* or *silt*,—not unfrequently they are occupied by waters, forming lakes and inland seas.

Narrow gorges and valleys occur in mountainous countries, from the splitting asunder of the strata by volcanic forces and in this case the rocks will be found to be of a similar kind on each side of the valley. But many valleys have been formed at different periods of time; and thus the rocks on one side may be very different from those on the other.

Valleys are generally the most fertile parts of countries, being filled up with rich soil, and usually watered by rivers.

The great deserts are the Sahara in Africa, the desert of Arabia, of Gobi in central Asia, and the plains of Patagonia.

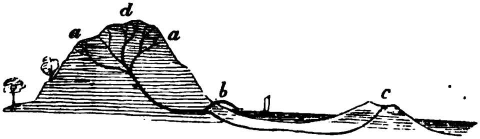
SECTION XI.—SPRINGS AND RIVERS.

Springs and rivers are formed of water, which has been distilled from the ocean in the form of rain.

Rain water is the purest of any, and is the original source of the supply of fresh water on the earth.

Water, like every other fluid, has a tendency, when left free, to seek the lowest possible level; thus rain falling on mountains and elevated ground gradually trickles downwards till it finds its original source, the ocean. And thus the surplus rain-water, not taken up by plants and animals, or re-evaporated into the air, is returned by rivers to the sea.

The soil and rocky strata being porous, much of the rain sinks below the surface,—in this manner it may be carried for many miles underground, and again reappear as a spring of running water.



Thus *d* represents a mountain, with numerous fissures, *a d a*, in the strata, through which the rain-water sinks, and again reappears at *b*; or the fissures may be continued for a long way below the sea, and appear on an island as at *c*.

In this manner, apparently isolated rocks and islands may furnish, by springs, a greater amount of water than all the rain which falls on their limited surface. Wells are thus formed by digging downwards, till a fissure, bearing water, is found; and this also is the nature of Artesian wells.

In districts where limestone and marble rocks exist, and which abound in large fissures and tunnels, a river frequently disappears at a particular spot, and runs for some distance underground.

Springs, both on the surface and underground, collect to form one or more streams; and these again join to form a river.

A river, in the first part of its course, is generally rapid and impetuous, frequently forming water-falls,—but it becomes calmer and more placid as it winds its way through low valleys and meadows to the ocean.

Pliny has thus compared a river's course to the stages in the life of man:—A youth of activity and impetuosity; a manhood of sedate usefulness; an old age of calm and dignified repose.

The stream of a river flows with a velocity of from one to two or three miles an hour. A mountain river may fall on an average from 10 to 20 feet of perpendicular height for every mile of its progress. The river, as it becomes wider and slower in its course in the valleys, has often a descent of not more than two or three inches in a mile. This is the case with the Amazon for many miles before it flows into the Atlantic.

The action of water has a considerable effect in wearing down the soil and rocks over which it flows,—hence rivers in the course of ages hollow out channels for themselves, not unfrequently changing their courses in consequence of obstructions occurring, and by repeated overflowings of their boundaries.

But, for the most part, the course of rivers is directed by hollow valleys and gorges already formed,—and thus arise the devious windings which they assume, in order that they may gain the easiest exit for their waters.

Almost all great valleys and plains are intersected by rivers.

An elevated mountain-chain, in the centre of a country, sloping to each side like the roof of a house, is called the *water-shed* of rivers. From this high ground rivers flow in various directions downwards to the ocean.

Thus the Alps form the principal water-shed of Europe. From one side issue rivers, which flow S. and S.E.; while on the other side, certain rivers flow W. and N.W. From the Grampian mountains of Scotland one set of rivers flow S.E., and another set flow N. and N.E.

(See Section XVI., p. 66.)

The most celebrated rivers of Asia take their rise in the great central mountains of Armenia, Hindoo-coosh, and northern Hindostan, and flow E. and S.E. through their respective plains.

This is the case with the Euphrates. The Tigris, the Indus, the Ganges, the Brahma-putra, have their origin in the Himalaya range. The principal Chinese rivers take their rise in the mountainous country of northern China, and flow south through its wide plains to the Chinese sea.

The rivers Obi, the Yenisei, the Lena, take their rise in the Altai Mountains, and flow N. through the level plains of Siberia to the Arctic Ocean.

In Africa, the Nile flows northwards from its supposed sources in the central Mountains of the Moon, and in the Nubian range; while the Niger, on the other hand, flows from the mountains of the western part of the continent in a S.E. course to the Gulf of Guinea.

From the high water-sheds in North America, and the rocky mountain-range in the N.W., a series of streams and rivers join to form the mighty Mississippi, which, after a south-eastward course of 3,600 miles, enters the Atlantic in the Gulf of Mexico, thus traversing one of the most extensive valleys on the earth, rich in metals, coal, limestone, and many valuable vegetable productions.

In South America, the chain of the Andes entirely influences the course of the rivers.

This great mountain-range intercepts the S.E. trade-winds, loaded with vapour, and almost all the moisture is deposited upon its eastern slopes.

From the east side of the Andes proceed a series of the most magnificent rivers in the world.

First, towards the north, is the Orinoco, fed by numerous tributaries from the Andes of Quito, as well as by many streams from the Parime mountains; traversing a distance of 1,600 miles, and latterly flowing through a valley of exuberant richness.

Next, the Amazon, rising in the mountains of Peru, traversing 3,000 miles, or nearly the entire breadth of the continent, and fed by tributaries which are in themselves, and even in their affluents, mighty rivers.

Such is the bulk and force of the Amazon's current, 180 miles broad at its mouth, that it flows out for 300 miles into the Atlantic, still preserving its waters fresh and uncontaminated.

A number of large tributary streams, taking their origin in the lagoons and marshes of the Pampas, near the W. of the central part of the continent, join to form the Parana or La Plata, which pursues a south-easterly course of 2,000 miles.

The rivers of Chile and Peru, on the west side of the Andes, are comparatively small and insignificant, and make but short courses ere they fall into the Pacific Ocean.

The general flow of rivers on the earth is in an easterly and southerly direction, because the highest portions of continents and islands are in most cases towards the N. and N.W., and the land slopes to the S. and S.E.

Examples.—The Danube, Dneiper, Po, Indus, Euphrates, Niger, Ganges, Mississippi, Amazon, and La Plata.

Most rivers that flow into the sea by wide estuaries form *deltas*, or accumulations of mud and sand (called *delta* from the Greek letter Δ).

During the periodical floods of rivers, which annually take place in the rainy seasons, these accumulations are greatly increased, and large trees and other vegetables are also swept along and embedded among the mud and sand.

The delta of the Ganges is 300 miles in length, and a mass of mud is annually carried into it, equal in bulk to 42 of the Pyramids of Egypt. The delta of the Mississippi extends for 100 miles below New Orleans, and hence into the Mexican Gulf.

All harbours formed at the mouths of rivers are liable to be continually silted up with mud.

The tidal wave flowing up the estuaries of rivers causes an agitation of the two meeting currents, called the *bore*.

Examples.—In the Amazon, South America; in the Severn in England; in the Solway Firth, Scotland.

Rapids are accelerated currents of rivers running along narrow and inclined rocky channels. They are common in the rivers of North and South America. Waterfalls are leaps which rivers make over precipitous rocks.

Niagara is the most extensive waterfall in the world. The river Niagara flows from Lake Erie into Lake Ontario, a distance of 35 miles. The falls are 22 miles from Lake Erie. The river at the falls is half a mile in width; Goat island divides the falls into two parts. The Horse-shoe fall is 1,800 feet wide—the other 600 feet. The height of the falls is 164 feet and 158 feet—about one million tons of water are discharged every minute.

The falls of the Missouri are 900 feet wide—the whole river dashes over a succession of falls of 50 feet in height.

The Montmorenci falls are 240 feet in height, and 60 feet wide at the top of the falls. The whole waters of the river dash over a perpendicular precipice, and appear one mass of snowy whiteness.

The cataract of the Rio de Bogota, in South America, is 800 feet in height, and the water is discharged through a narrow rocky chasm.

The small river Ache, in Bavaria, has a perpendicular descent of 1000 feet. The fall of Garispa, in India, is 1000 feet.

Terni in Italy, has a descent of 800 to 900 feet by 3 falls.

In Scotland, the falls of the Clyde at Lanark, are the most considerable. The fall of Foyers, Inverness-shire, has two cataracts of 40 and 90 feet in height.

Thermal or hot springs issue from the earth in various countries, of a temperature from 100° to 209°; the deepest springs being the hottest. The water is generally impregnated with salts. The boiling springs of Iceland, and the mud volcanoes of China and Trinidad, are of this description.

Lakes are formed in hollow basins of the earth, which collect and retain rain-water, and the water of springs, or melted glaciers. They occur on flat mountain-tops, table-lands, or in valleys, and the excess of their waters is drained off by rivers, or by evaporation.

Lakes generally consist of fresh water. The largest fresh-water lakes in the world are those of North America.

They form a chain from N.W. to S.E., are connected together, and fed by rivers, and have a descending level from one lake to the other. Lake Superior lies most inland, at a height of 728 feet, and is succeeded by Michigan, Huron, St Clair, Erie, and Ontario; their total surface forming 93,000 square miles of water. Their surplus waters are discharged into the ocean by the river St Lawrence. They are all navigable for ships of the largest size.

Lake Titicaca, in South America, is at an elevation of 12,946 feet; Sir-i-col Lake, central Asia, is at a height of 15,600 feet.

For picturesque beauty, the lakes of Geneva and Lucerne, in Switzerland—Como, in Italy—Windermere and Grasmere, in Cumberland—Killarney, in Ireland,—and Loch Lomond, Loch Katterin, Loch Awe, and Loch Tay, in Scotland, are pre-eminent.

Inland Seas are collections of salt water, and are either connected by narrow straits with the ocean, as the Baltic, the Mediterranean, the Black Sea, the Red Sea; or are isolated and unconnected seas, as the Caspian, the Aral.

The continents of Europe and Asia are much more broken up and indented with arms of the ocean than those of Africa and America, or than the land of Australia, neither of which contain inland seas.

The water of inland seas is generally salter than that of the ocean, and from their comparatively small surface, they are not subject to tides. Those unconnected with the ocean are fed by rivers flowing into them, and their surplus water passes off by evaporation.

The Caspian Sea is 83½ feet below the level of the Black Sea; and the surface of the Dead Sea is 1,311 feet below the Mediterranean, with a depth of about 1,000 feet, thus forming the lowest known portion of the earth.

SECTION XII.—CHANGES OF THE EARTH'S SURFACE.

VOLCANOES.

The surface of the earth is slowly, but continually, undergoing changes; and this has been the case in the ages that are past, as well as at present.

The surface of the dry land is incessantly crumbling down into sand and dust by the action of the air and moisture, by frost splitting up rocks, and by the abrading force of rivers and the ocean.

In the course of time, these processes would level all continents and islands, and sweep them into the sea. But to counteract this, other processes are also going on.

Coral island, or Atoll, with lagoon in the centre.

Minute animals (*Coral Zoophytes*) are building up masses of coral in tropical seas, forming reefs of thousands of miles, and circular islands or *atolls*.

This they do by extracting lime from sea water, with which they form their coverings or houses, one piled up on another like the branching stems of a tree.

These coral reefs entangle floating trees and sea-weeds, and, in time, a soil is formed, in which seeds, also floated on the waves, take root, and grow into trees and plants, and sea-birds shelter among them; till at last they are taken possession of by man.

On land, too, vegetables, by their growth, serve somewhat to protect the earth's surface, and, by their decay, to add to the soil.

The great agent, however, of elevation, and renewal of the surface, is volcanic action.

Volcanoes are found in every region of the globe—from the regions of the North to the newly-discovered land in the Antarctic Circle.

There are computed to be at least 260 volcanoes in activity at the present day.

A volcano is a mountain with a hollow summit or *crater*, which emits, at intervals, streams of melted rock or *lava*.

Mud, watery vapour, and sulphureous gases, are also ejected.

View of the crater of Vesuvius, near Naples.

Such volcanoes are called *active;* other mountains having the volcanic form, but which have not emitted lava within the period of history, are called *extinct*.

View of the several volcanic cones of Mount Etna, in Sicily.

Earthquakes, or trembling movements of the ground causing fissures, and either an upheaval or sinking of the surface, generally accompany or precede volcanic action; and both arise from the same cause.

An intensely heated state of portions of the interior of the earth's crust, causing the melting and the great expansion of the mineral matter within, gives rise to earthquakes, and the bursting out of volcanoes.

Chemical action, arising from the combination of the simple metallic bases of the earths and alkalis with oxygen, derived from the decomposition of water; or the accumulation of electric matter, transmitted in currents along the strata in the interior, have been assigned as causes of volcanic explosion.

The force of this internal heat and commotion frequently extends for many hundred miles, and is propagated in a succession of impulsive waves, which succeed each other at intervals, generally in a direction from W. to E.

By some such forces acting from below, and repeated at various intervals of time, all the islands and continents of the earth's surface have been elevated.

We accordingly find in every region of the earth, strata which have evidently been raised out of the bed of the sea, for they contain abundance of shells and fishes, and portions of trees and vegetables, now converted into coal, but which had grown on formerly existing land, and had been floated down into the sea by rivers. Coral and shell limestone, rock-salt and petrified fishes, found in these stratas, all attest the former dominion of the sea.

Various elevations and depressions, as also re-elevations, can thus be traced throughout all existing continents, and thus the face of the earth must have undergone successive changes.

Graham Island.

An island, with a volcanic crater in the centre, suddenly appeared in the ocean off the Lipari Islands, Sicily, in 1831, and, after remaining for several months, was finally washed away by the action of the waves.

Volcanic mountains are, with a few exceptions, generally found near the sea-shores of continents, or in islands.

Examples.—Vesuvius, Etna, Hecla, the Andes, Sandwich Islands.

Volcanic mountains are distributed in groups or chains—sometimes, but rarely, a volcano is found isolated. Such volcanic chains may extend for 500 or 1000 miles.

The most remarkable volcanoes in Europe are—Etna in Sicily, Vesuvius in Italy, Hecla in Iceland, Esk Mount, Jan-Mayen Island. The continent of Asia contains only one or two volcanoes, but the Malay Islands, the Philippines, the Aleutian, Kurile, and other groups, are all volcanic. In Africa no known volcano exists, but several in its adjacent islands. In America the mountain range on the west coast from north to south is one chain of volcanoes. In Polynesia are numerous active volcanoes.

TABLE OF THE MOST REMARKABLE ACTIVE VOLCANOES.

EUROPE AND ATLANTIC ISLANDS.	Height in English Feet.
Etna, Sicily,	10,874
Vesuvius, Naples,	3,948
Chicciolo, Island of Stromboli,	2,957
Esk Mount, Island of Jan-Mayen,	6,874
Hecla, Iceland,	5,110
ASIA AND ISLANDS.	
Demavend, El Burz Mountains,	14,695
Ararat,	17,112
Galuny Gung, &c., Java,	7,039
Singallang, &c., Sumatra,	15,000
Asama Yama, Island of Niphon,	12,000
Kamtchatskaya,	15,763
Pico, Azores,	7,808
Canary Islands, African coast,	8,815
AMERICA AND AUSTRALASIA.	
St Helens, Columbia River, North America,	
Jorullo, Mexico,	4,265
Toluca, ditto,	15,168
Popocatepetl, ditto,	17,720
Atitlan, Central America,	12,500
Agua, ditto,	15,000
Ostrowa, Aleutian Islands,	3,000
Pichinche, South America,	15,920
Antisana, ditto,	19,150
Cotopaxi, ditto,	18,880
Maunu Roa, Hawaii Island,	13,120
Mount Egmont, New Zealand,	9,630
Salomon Island,	12,000
Mount Erebus, S. Victoria Land, Antarctic sea,	12,400
Mount Terror, ditto,	10,880

SECTION XIII.—DISTRIBUTION OF PLANTS.

Plants and animals are living organised beings, flourishing on the surface of the earth.

Plants, by which are meant all kinds of vegetables and trees, have organs—as roots, leaves, stems—by which they convert the air, water, and portions of earth into organic matter fit for the food of animals; all animals living directly or indirectly on vegetable substances.

The greater proportion of animals live on grass, leaves, roots, and bark of trees, fruits, nuts, seeds, especially grain. The smaller proportion of animals live on the flesh of other vegetable-feeding species.

Plants depend for their existence upon heat, light, moisture, and a few earthy substances.

Plants are, therefore, distributed on the earth's surface, according to the requirements of their proper food, and their peculiar natures.

Vegetation is most rapid and most luxuriant within the tropics. In those regions are found palms, sugar-canes, spices, rice, maize, and various fruits that require great heat and moisture; and, beyond the limits of the torrid zone they will not grow naturally.

In the temperate zones, wheat, barley, oats, grasses, the vine, apple, and similar fruit-trees, the oak, elm, beech, fir, and potatoes, turnips, and similar vegetables, flourish. Vegetation, in these regions, is also luxuriant during summer; but almost ceases during winter, when trees and shrubs generally shed their leaves.

In the frigid zones, trees, except birches, beeches, alders, and a few others, almost entirely disappear. Heaths and moss plants, and grey lichens, on the rocks, are abundant; grass grows in summer; and on the boundaries of the arctic regions and the temperate zones, barley and oats still flourish in the valleys.

Vegetation is however here slow and scanty, and ceases for the greater part of the year, except a few months in summer, when every plant bursts into leaf, and hurries on its course to maturity.

Vegetation ceases near the poles in about latitude 75° in the northern hemisphere; while in latitude 59° in the southern hemisphere, no traces of vegetation are found.

Barley grows in Norway in latitude 70°, in the plains near the sea shores.

Plants have also a *perpendicular* distribution, in an order corresponding to their distribution in zones of latitude.

Thus, in a high mountain-range within the tropics, the lower part of the mountain is covered with palms, orange-trees, sugar-canes; the middle part with oaks, elms, and firs; the higher part with birches, mosses, and lichens—till at last the line of congelation is reached, where vegetation entirely ceases.

Wheat will not generally ripen in Britain beyond an elevation of 800 to 1000 feet.

Besides the localization according to climate, plants are also distributed in distinct groups in certain regions of the earth.

Thus the plants of Australia are mostly peculiar to that region—the plants of South Africa differ from those of North America—the plants of New Zealand from those of Britain.

The remains of plants found in the coal of Great Britain, indicate different species from those now growing in this country; and the same applies to the coal-plants throughout Europe and North America, indicating that change of climate and form of country, have been accompanied by a change of vegetation.

SECTION XIV.—DISTRIBUTION OF ANIMALS.

Animals are subject to the same laws of climate as plants, and are similarly distributed.

The torrid zone is as full of animal as of vegetable life; the influence of heat, light, and abundance of vegetable food, tending to their increase. The minuter beings—as molluscs, insects, reptiles, birds—swarm in great numbers; together with animals of gigantic size—as the elephant, camel, rhinoceros, camelopard, buffalo, tapir, hippopotamus. Here, too, is the region of animals of prey—as the lion, tiger, puma, hyena, and the vulture, condor, rattlesnake.

The temperate zones are favourable to all herbivorous quadrupeds—as the horse, ass, ox, buffalo, deer, sheep; to numerous birds, and various tribes of the lower animals. The wolf, fox, lynx, bear, otter, are the chief beasts of prey.

Animal life decreases rapidly as we advance to the polar regions. There the larger quadrupeds and birds are only summer visitants—as deer, elks, buffaloes. Bears sleep out the winter in a state of inactivity. The beaver makes for itself a warm house, and a few foxes and wolves only roam over the dreary snows. Insect life is scarce. Seals, whales, and innumerable medusæ, inhabit the ocean, whose waters are, even here, more genial than the freezing air.

Animals observe also a *perpendicular* arrangement, according to height above the sea-level; occupying different zones of mountains in a similar way as plants.

Animals are also grouped in particular centres, pouched animals—such as opossums and the kangaroo, being peculiar to Australia and South America. The camelopard is peculiar to South Africa, and the hippopotamus to the rivers of that continent. The birds of Africa differ almost entirely from those of America, and these, in many species, from those of Europe.

MAN, sprung originally from one family, is dispersed over every region of the globe, and is adapted, by his constitution as well as by his science and art, to occupy almost every habitable locality on the earth's surface. He is found in the torrid zone, in the temperate, and even on the extreme borders of the frigid regions. He can live in valleys, on the seashore, and at elevations from 100 feet to 14,000 and 15,000 feet above the earth's surface.

The city of Potosi, South America, is 13,330 feet above the sea; Quito, 9,543; Mexico city, 7,570. Some localities in the Tibetian mountains are inhabited in summer at a height of 16,000 feet. In Europe, the Hospital of Great St Bernard, in the Alps, is 8,110 feet above the sea; the city of Madrid is 1,944 feet. The highest habitable positions in Britain do not exceed 1000 ft.

Man, however, has been separated into races having peculiar distinctions of colour, features, and language, and these races are found occupying different regions of the globe.

Thus the white races inhabit Western Asia and Europe. The region of the Negro or black race is Africa. That of the tawny race (*Mongolians*), Eastern Asia. That of the red races, America; the Malay race is spread over the Indian and Polynesian Islands.

Assuming that the population of the whole earth amounts to about 900 millions, it may be thus divided into leading races:—

White (*Caucasian race*), .	350 millions.
Tawny (*Mongolian*), . .	420 ...
Negro (*Ethiopian and Papuan*),	100 ...
Malay and American, . .	30 ...

In America, there are, on an average, 4 individuals to every square mile of country; in Africa, 6; in Asia, 36; and in Europe, 66. In China, there are 276 individuals to the square mile; in England, 275; in France, 167; in the island of Barbados, 734.

SECTION XV.—PHYSICAL GEOGRAPHY OF EUROPE.

The continent of Europe lies within the north temperate zone, with the exception of a small portion within the limits of the north frigid zone.

On the E. it is joined to the continent of Asia, but on all other sides it is surrounded by the ocean, and is generally deeply indented with bays, firths, and inland seas. In this way the greater proportion of its territories have all the advantages of an insular situation.

The S. and S.W. portions have the most genial climate.

The greatest quantity of rain falls in the region of the Alps; about Coimbra, in the centre of Portugal, the W. side of Britain and Ireland, and the N.W. coast of Norway.

The annual fall of rain in these localities amounts to from 30 to 40 inches; on the S. declivity of the Alps, to 57 inches; on the Norway coast, to 82 inches.

The least quantity of rain falls in Germany, Russia, and the eastern parts of Europe. The annual fall of rain, at St Petersburg is 16 inches.

The Alps are the highest mountain-range of Europe.

Mont Blanc is 15,810 feet in height. The snow line commences at 8,500 feet. Monte Rosa is 15,585 feet.

The Alps and surrounding high land form the great watershed of many of the principal rivers of central Europe. Their summits, covered with perpetual snows and glaciers, afford an inexhaustible source of springs which flow from their sides.

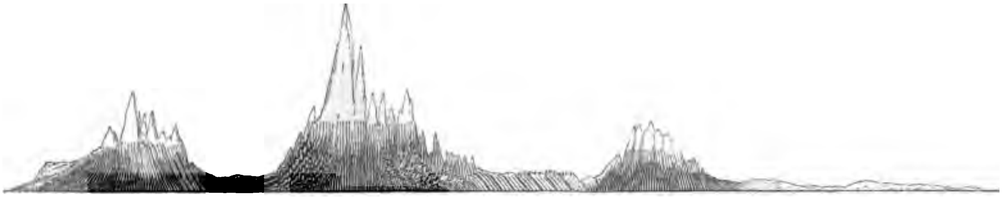
The principal rivers of Europe, which flow W. and N.W., are the Weser, Elbe, Rhine. The principal rivers which flow S. and S.E., are the Rhone, the Danube, the Dneiper, the Po.

The central part of the peninsula of Spain is an elevated table-land of 2,300 feet above the level of the sea.

The Apennines traverse the greater part of the centre of Italy. The Pindus chain of mountains extend through Greece.

The central and northern parts of Russia and Siberia constitute an immense level plain of alluvial soil, clay, sand, and marshes, with no hills higher than 1,300 feet.

SECTION OF EUROPE, FROM CADIZ ON THE S.W., TO THE PLAINS OF RUSSIA ON THE N.E.



In this section, cutting across the centre of Europe, the Alps appear the culminating point, with their peaked summits towering above the snow line. The strata D D, of newer formed limestones, are seen raised, and very much contorted by the action of central granitic rocks G. A is the valley of the Rhone, opening into France, and containing coal, salt, and gypsum. B, the table-land of Spain. C, Cadiz. E E, the basin of the Dnieper, and the extensive level plains of Russia, extending to the Arctic sea.

The Mediterranean is the great inland sea which extends along the south part of Europe, and which separates this continent from Africa. It has no tides, and its waters, from the great amount of evaporation, are salter than those of the ocean. It communicates with the Atlantic through the Strait of Gibraltar, in which a strong current prevails.

The Mediterranean has been, from the earliest periods, the great medium of communication among the various races of mankind, and has afforded the most eminent facilities for the spread of civilization and commerce. The Phœnicians, the Tyrians, the Arabians, the Venetians, the Genoese, and the modern nations of Europe, have all traded in the Mediterranean. It was anciently the only known tract to India, and has in modern times again become the most direct way to the countries of the East.

Iron, copper, and lead, are found in Sweden—gold and silver in Hungary—coal in France, Spain, Belgium, Germany, Russia.

The orange, pomegranate, vine, olive, sugar-cane, maize, and even the dwarf palm, grow in the south of Europe. The oak, elm, birch, pine, ash, and the grains and grasses, grow luxuriantly in most localities of this continent. The immense pine forests of northern Europe produce timber, resin, turpentine, and tar. The principal wild quadrupeds of Europe are the different species of deer, the chamois, wild boar, wolf, fox, lynx, wild cat.

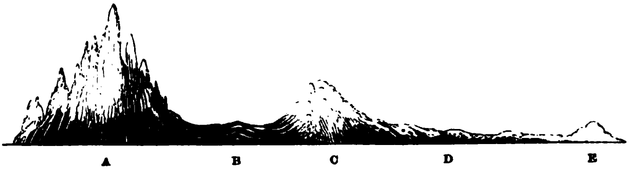
The races of man in Europe are:—the *Teutonic* or *German;* with fair-complexion, light hair, blue eyes, broad forehead, large-limbs; steady, persevering, and industrious; inhabiting central Germany, Belgium, Holland, Norway, Sweden, Denmark. The *Celtic;* dark-complexion, of middle-size, with slender make, with dark hair and eyes, oval face and head; active, volatile, energetic, but less persevering than the Teutonic; inhabiting Italy, Spain, Portugal, France, Ireland, part of Wales, and Scotland. The *Slavonic;* with dark, rather sallow complexion, grey or hazel eyes, dark, rough hair, square form of face and head, stout frame of body; possessing mechanical and imitative talent; fond of country, but of slovenly habits; inhabiting, Russia, Poland, Illyria, Servia, Dalmatia.

Of the total population of Europe, comprising 230 millions, about one-third are Teutonic, one-third Slavonic, one-fourth Celtic, and the remainder Magyars, Tartars, and Jews.

SECTION XVI.—THE BRITISH ISLANDS.

The British Islands, surrounded on all sides by the ocean, enjoy a temperature much milder than their northern situation would otherwise permit. England is traversed in the centre by hills of moderate elevation. The western part, or Wales, is mountainous; but the country becomes low and level towards the E. The majority of its rivers flow eastward, as the Thames, Trent, Humber, Ouse, Tyne; others flow towards the W., as the Severn, Medway, Dee, Mersey.

Section of England from Wales on the W. to the Norfolk Coast on the E., about 420 Miles.



A, Welsh mountains, Snowdon, 3,557 feet in height. B, Western and Midland Counties, containing coal, iron, salt. C, Derbyshire, &c., mountain limestone. D, Lias and oolite. E, Norfolk, &c., Chalk.

England may be divided into three regions; the *western*, principally Wales, and the *N. western*, Cumberland, &c., which are hilly, composed of primary strata, abounding in granite, roofing slates, copper, tin, lead, and other metals, with a moist climate and soil adapted for pasturage. The *middle*, which is less hilly, composed of secondary sandstone, abounding in coal, ironstone, salt, clay, and lime; partly a grain and pastoral district, and the great seat of arts and manufactures.

The *eastern*, a level alluvial country, with climate and soil adapted for raising grain; the great seat of agriculture.

The north, west, and south parts of Ireland are hilly, but its general aspect is level, with numerous lochs and morasses in the centre; with a moist but mild climate, fitted both for pasturage and agriculture. The Shannon flows through the centre.

The western and middle parts of Scotland are pastoral and grazing districts; the valleys and eastern shores agricultural.

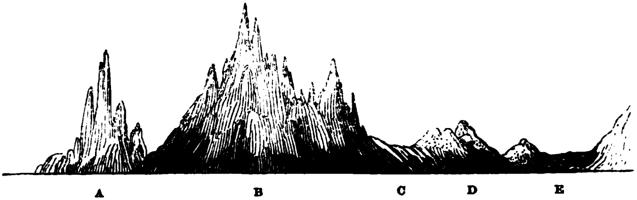
In Scotland, the western part is also the most elevated, and the country slopes to the E. The Grampian Mountains intersect the northern division from S.W. to N.E.

The principal central rivers flow S.E.,—as the Tweed, Forth, Tay, Esk, Dee, Don; on the N. side of the Grampians, the rivers flow N. and N.E.,—as the Spey, Findhorn, Ness.

The South of Scotland is also traversed by the mountain-ranges of the Lanarkshire, Dumfries-shire, and Lammermuir hills.

The Lanarkshire hills form the water-shed of the Tweed and its tributaries, which flow S.E.; and of the Clyde and its tributaries, which flow N.W. The Nith and Annan flow S.

SECTION OF SCOTLAND FROM CAPE WRATH TO FIRTH OF FORTH, ABOUT 200 MILES.



A, Ross-shire Mountains. B, Grampians, (*granite*) C, Perth and Forfarshire, (*old red sandstone*). D, Ochil Hills, (*greenstone*). E, Coal-fields of Fife and Lothian.

Less rain falls on the eastern coasts of Britain than on the western.

The annual average of the E. coast is 25 inches. That of the W. coast is 36 inches. In Cumberland, the annual fall of rain is 55 inches.

The winter and spring temperature on the E. coast is more chill than that on the W. and S.W.

These facts are to be explained on the general principles announced in Sections IV. V.

Table of mean annual temperature of British Islands.

	England.	Scotland.	Ireland.
Mean winter, .	39° .5	39° .4	39° .9
Mean summer, .	60° .8	58° .1	60° .5
Mean of year, .	49° .7	47° .9	49° .6

The annual quantity of coals raised in Britain amounts to 32 million tons; of iron, 2 million tons; of copper, lead, and other metals, 70,000 tons.

The British islands appear to have derived their plants and wild animals from the continent of Europe, with which, probably, Britain was at a remote period connected. The wild boar, wolf, beaver, and elk, once inhabitants of the country, are now extirpated; the deer, fox, hare, rabbit, weazel, otter, wild cat, being the principal wild quadrupeds now existing.

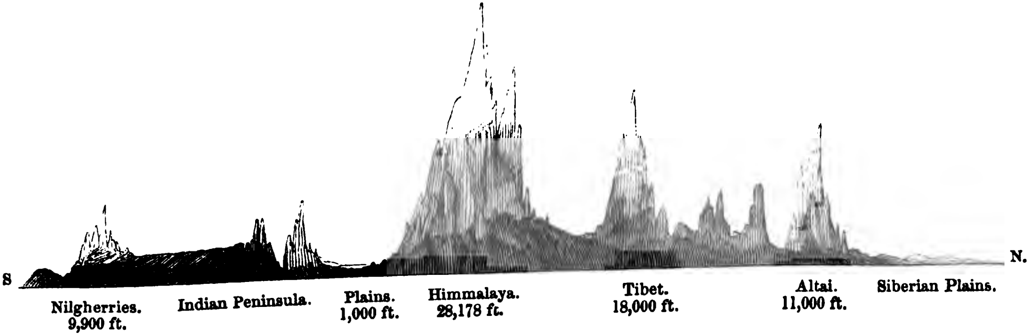
A mixed Teutonic race of Saxons, Scandinavians, Normans, and a proportion of Celts, form the population of England. The same races inhabit the southern, eastern, and middle portions of Scotland. In the north-west and north, the original Celtic race is still prevalent. In the north of Ireland, and skirting its eastern shores, are a mixed Teutonic race; the remainder are aboriginal Celtic inhabitants.

Britain is remarkable for its free constitution, its maritime and manufacturing industry, and for its spirit of colonization.

SECTION XVII.—ASIA AND ITS ISLANDS.

The continent of Asia extends from the polar regions to within a few degreees of the equator, and thus comprehends all varieties of climate.

SECTION OF ASIA, FROM CAPE COMORIN ON THE S., TO THE PLAINS OF SIBERIA ON THE N.



The Continent of Asia, as viewed in section, from S. to N., presents the most elevated land on the earth, with great irregularity of surface. The central and oldest portions of the mountains are formed of granitic rocks, but more recent volcanic rocks are interspersed, and strata of limestone recline on their sides, of comparatively recent formation. The limit of the snow-line on the S. side of the Himmalaya, which is lower as compared to the limit on the N. side, is indicated in the diagram.

The centre of Asia forms the highest known land on the earth, rising into the peaked mountains of the Himalaya and Hindoo-Coosh, and also the extensive table-lands of Tibet. Towards the north-west it slopes into the vast plains of Siberia.

The great rivers of Asia,—those that flow S. and S.E., and those that flow N. and N.W., may here again be pointed out.

(Sect. XI., p. 48, 50.)

The central table-lands are arid tracts, with occasional fertile valleys, and from the Ural mountains and Caspian Sea on the W., to the Himalaya mountains on the S., and the Aldan mountains on the E., form the country of the Mongolian or Tartar races, composed of wandering pastoral hordes, having few or no cities. On the south-east are the more civilised Chinese, Japanese, and Siamese. These Mongolian races constitute at least one-third of the human family.

Syria, Persia, Arabia, and Hindostan, constitute western and southern Asia.

Syria and Palestine, situated along the eastern shores of the Mediterranean, enjoy a delightful climate, are moderately elevated, and watered by several rivers, of which the Jordan is the most famous. The palm, olive, vine, cedar, pomegranate, flourish in these regions; and maize, rice, wheat, find a congenial soil and climate, but the land is now comparatively desolate and uncultivated.

Arabia is in a great measure arid and desert, but famed for the production of coffee, dates, gums.

The Syrians and Hebrews are the descendants of Shem (*Semitic race*); who have held such a conspicuous place in the sacred history of mankind. The Arabs are a branch of the same great family.

Persia is mountainous, dry, hot, and, except in favoured valleys, sterile.

Hindostan, or India-Proper, forms the great peninsula of Central Asia. The land slopes from the Himalaya range on the north, into a great triangular plain or table land, with the Ghauts mountains, on the west and east shores.

The majority of the rivers flow S. and S.E., a few only taking a W. course.

Rice, sugar, indigo, spices, opium, the orange, lemon, manga guava, and a variety of other fruits, are produced in great abundance, as also wheat and other grains.

The Hindoos, though of dark complexion, are more allied to the Persians, Celts, and European races, than to any other variety of mankind. They are intelligent, ingenious, and generally docile and industrious.

The Asiatic Archipelago contains the largest collection of islands on the globe, lying south and south-east of the Asiatic continent, and grouped on each side, north and south of the equator. The temperature is elevated, but considerably modified by the surrounding ocean. Volcanoes are common, and earthquakes occasionally occur. Gold, tin, and other metals are found on many of the islands. The seasons are varied by the periodical returns of the monsoons, and the N.E. islands are within the range of the tropical hurricanes.

Sumatra and Java form the chief of the western group; Borneo and Celebes the central. The Molucca, or Spice Islands, lie to the east, and the Philippines to the north-east.

Tropical trees,—as palms, bamboos, teak, and sandal-wood; fruits,—as the orange tribe, guava pine-apple; spices,—as nutmegs, cloves, cinnamon, pepper, ginger, sugar-cane, gums, caoutchouc, gutta-percha, maize, rice, sago, with flowering plants of the most splendid hues,—grow in abundant luxuriance.

Among animals are the elephant, rhinoceros, tiger, panther, ox, buffalo, deer, hog; the monkey tribe and oranoutang; innumerable birds of glowing plumage, reptiles, and insects abound. The population consists of Malays, a race who partake of the characters both of the Hindoo and Eastern Asiatic or Mongolian. In many of the islands the Papuan negro race are also found.

SECTION XVIII.—AFRICA.

Africa is placed more within the torrid zone than any other of the continents. It has few indentations of its shores, and its climate is more generally continental than insular. It is the hottest country on the earth. The great Zahara is an arid desert, and much of the interior is unexplored. The Nile on the N.E., and the Niger on its S.W., are its great rivers.

Many of its animals are peculiar to it; as the hippopotamus, camelopard, gnu or wild ox. Among its plants, acacias, mimosas, tamarisks, and most splendid heaths, are conspicuous.

Africa is the country of the negro race; but in Abyssinia, Ethiopia, and its north-western coasts, mixed races of Arabs and negroes prevail; while in South Africa the Caffre, Hottentot, and Bosjesman races are found.

SECTION XIX.—AMERICA.

The American continent extends from the north frigid zone southward, across the equator, over a considerable space of the south temperate zone, and thus possesses every variety of climate of both hemispheres. North America extends over the arctic and temperate zones. Its elevated portions are the rocky mountain range on the west, the Alleghanies on the east, and elevated land in the parallel of the lakes, and to the northward.

Rocky Mountains (*Granitic*), 15,990 feet. Mississippi Valley, coal, salt, metals. Alleghanies (*Greenstone*), 6,620 feet.

The great valley of the Mississippi occupies the centre of the country. A chain of fresh-water lakes extends across a portion of the north-eastern continent, and the centre of the valley is one immense coal-field, with limestone and sandstone strata, covered by many feet of rich vegetable mould.

Gold and quicksilver abound in the mountains of California; and copper, lead, and iron in the United States and Canada.

The climate of the eastern and middle parts of N. America is of a continental character: the cold of winter being severe, and the heat of summer great. On the western coast the moist breezes of the Pacific Ocean greatly mitigate the temperature.

In vegetable and animal life the northern parts of Central America correspond somewhat with the north of Europe and Asia. The oak, elm, beech, sycamore, birch, and magnificent pine trees, abound; to which are added the splendid magnolia, the liriodendron or tulip-tree, the locust-tree, the rhododendron, azalea, hydrangea, and numerous flowering shrubs; but it is remarkable for the total absence of heaths.

The buffalo, deer, beaver, martin, fox, bear, and puma, are among its most remarkable quadrupeds; but, until introduced by Europeans, the horse, ox, goat, sheep, were unknown.

Central and South America are both characterised by a chain of elevated mountains, which traverse the western shores of the continent, and in which there are numerous volcanoes. These mountains are rich in gold, silver, quicksilver, platina, lead, and other metals.

Bolivian, Andes, 23,910 feet.
Snow line, 15,000 ft.

Valley of the Amazon.

Brazil Mountains.

The middle region of South America is one vast plain, sloping by successive terraces eastward to the Atlantic, and intersected by numerous large rivers, some of whose tributary streams exceed in size the largest rivers of Europe.

Part of Brazil, on the eastern side of the continent, is also elevated into considerable mountain ranges.

Gold, silver, platina, quicksilver, and copper, are found in the Andes; the diamond, topaz, emerald, amethyst, in Brazil.

The climate of Central, and a considerable part of South America, is tropical,—with a heat, however, inferior to that of the tropics of the Old World. The southern parts of Chile and Patagonia are damp, bleak, and cold.

Nothing can exceed the rich profusion of the vegetation of South America, especially in the valleys of the Orinoco and Amazon. Palms, sugar-canes, cacao, mahogany, the Peruvian bark tree, dragon tree, and many others, flourish in the greatest luxuriance; while maize, rice, coffee, wheat, and other grains, are the products of cultivation. To Chile we owe the potato, which there grows wild on the shores and islands. The puma, called the lion of the New World, leopards, lynxes, the llama, vicuna, and opossums, are among the most remarkable quadrupeds; the most noted birds are the condor, the ostrich, the eagle, and innumerable humming-birds; the cayman, the boa-serpent, the rattlesnake, the turtle, and tortoise, are its most remarkable reptiles.

Various tribes of the Red Indian, the original possessor of the New World,—in different degrees of civilization, occupy the country from the arctic regions to Patagonia. The Mexicans and Peruvians were the farthest advanced in civilization; but all the races appear to have the same general physical character, and speak dialects of one common language. The original races are now fast giving way to European settlers in North America,—in South America they have partly become mixed with their Spanish conquerors.

SECTION XX.—AUSTRALASIA AND POLYNESIA.

Australia may be looked on as a fifth continental land, surrounded by its islands. Like Africa, it is sparingly indented with bays or arms of the sea. It is generally a flat country, with few mountains or large rivers; copper mines of great richness are found at Adelaide. Its climate is dry and temperate; the air pure and wholesome, but it possesses a less luxuriant vegetation than that of America. Most of the trees are evergreens, many of them with exceedingly small leaves. There are a few palms and tree-ferns. The islands contain the majestic Araucaria and other pines.

Pouched quadrupeds—as the kangaroo and opossum—prevail in Australia; the emu rivals the ostrich in size; and the duck-billed ornithorynchus, half quadruped half bird, is an anomalous animal, not found in any other region.

Polynesia embraces those multitudes of small islands which are grouped along the Pacific, and which extend for a thousand miles from E. to W., along the boundary of the torrid zone.

These islands are chiefly of coral formation,—many of them elevated by volcanic action, and containing volcanoes in active operation. Their insular character, in the centre of a wide ocean, imparts a delightful mildness and salubrity to their climate, rendering many of them in this respect the choicest abodes on earth.

Though their original stock of trees and plants is small in number, yet vegetation is most luxuriant. Palms, bread-fruit trees, plantains, bananas, taro, and yams, afford spontaneous food in abundance. The bark of the paper mulberry-tree furnishes garments; and other timber trees, for domestic use, are abundant. Their original stock of quadrupeds consisted only of the pig, dog, and rat.

The inhabitants are chiefly of Malay descent; and though, when first discovered, they were savage cannibals, are now found very susceptible of education and religious instruction.

There is another race in some of these islands called Papuan, having all the characters of the negro, or more properly resembling the natives of South Africa; whence, by way of Madagascar, Sumatra, and Java, they are supposed to have entered the Pacific.

* * *

The leading characteristics of the continents, taking them generally, may be stated thus :—

Europe, temperate, moderately moist, maritime, moderately elevated, with numerous plains.

Asia, greatly elevated, mountains, snow-capped; warm, dry.

Africa, hot, desert, arid.

America (N.), extensive lakes, rivers, and fertile valleys.

America (S.), mountainous, volcanic, hot, humid, with profuse vegetation.

Australia, level, dry, few mountains, or rivers.

APPENDIX.

I.

EXPLANATION OF TERMS.

Artesian Wells—from Artois, a town in France. Water procured by boring through strata.

Atmosphere—*ατμος*, vapour; *σφαιρα*, a sphere.

Electricity—Electric—*ελεκτρον*, amber, the first body remarked to possess this property.

Hemisphere—Ἡμι *σφαιρα*, a half sphere.

Isothermal—*ισος*, equal; *θερμη* heat.

Mean or *average* is the amount of any number of terms divided by the number of terms—thus the sum of the terms 2, 3, 5, 10, divided by 4, gives the mean of the terms 5.

Meteorology—*μετεωρος*, sublime, lofty; *λογος*, a discourse; embracing a history of the atmosphere.

Monsoon—from *Mousun*, Persian, alternation of season.

Oblate spheroid—depressed at the poles, and elevated at the equator.

Organic—having *organs* and life, as plants and animals.

Plateaux—French; elevated table lands.

Volcano, so named from Vulcan, the god of fire.

The pupil should be early accustomed to scientific terms. As this is one of the uses of early training, nothing can be more absurd than the attempts of some elementary works to dispense with the usual and proper scientific terms; it is an effectual means of preventing progress in after-life.

II.

THE SOLAR SYSTEM.

Planets.	Discoverers.	
Mercury,	Known to the ancients.	
Venus,		
The Earth,		
Mars,*		
Flora,	Hind,	1847.
Vesta,	Olbers,	1807.
Iris,	Hind,	1847.
Metis,	Graham,	1848.
Hebe,	Hencke,	1847.
Astræa,	Do.,	1845.
Juno,	Harding,	1804.
Ceres,	Piazzi,	1801.
Pallas,	Olbers,	1802.
Jupiter,*	Known to the ancients.	
Saturn,*		
Uranus,*	Herschel,	1781.
Neptune,*	Leverrier, Adams,	1846.

* Those so marked are larger than the earth.

III.

TABLE OF THE MOST PREVALENT SUBSTANCES IN NATURE.

Oxygen, or vital air,		*Aeriform*—forming the Atmosphere.
Nitrogen,		
Carbonic acid		
Oxygen,	Water,	*Fluid*—forming the Ocean, &c.
Hydrogen,		
Oxygen,		*Solid*—forming Rocks, Minerals, and Soil.
Silicon (flint),		
Chlorine,		
Sodium,		
Aluminum (clay),		
Carbon (charcoal),		
Iron,		
Potassium,		
Calcium (lime),		
Magnesium,		
Sulphur,		
Phosphorus,		
Fluorine,		

IV.

THE BAROMETER.

(Βαρυς, weight; μετρον, a measure.)

The barometer consists of a tube of glass, sealed hermetically at one end, and open, or formed into a turned-up cup, at the other, and somewhat more than 31 inches long. It is filled with pure quicksilver from the open end, and after all air has been carefully expelled by heating and shaking the tube, it is turned with the sealed end uppermost. The mercury now falls to its ordinary level, and leaves an inch or two of perfect vacuum at the top. The tube then becomes a measurer of the varying density of the air; because a column of mercury of from 30 to 31 inches balances a column of air equal to the whole height of the atmosphere.

When the air is still and cool throughout it is heavy, and presses the column of mercury so that it rises. This is the case in steady fair weather, either in summer or winter. If the air be unequally agitated by currents, or hot and humid, its elasticity is diminished, its pressure is less, and the mercurial column sinks. This is the case previous to and during high gales, hurricanes, excessive heat, heavy rains, or a generally moist state of the atmosphere, for although moisture would of itself add to the weight of the air, yet a moist air is always a warm one. Sudden electric changes also in the atmosphere have the effect of diminishing its elasticity, and thus the mercury falls before thunder-storms.

The mercury stands highest at the sea-level, and higher towards the poles than at the equator. Every 90 feet of ascent into the atmosphere sinks the mercury about one-tenth of an inch.

In this way the barometer is used to ascertain the heights of mountains, taking an observation at the base of the mountain and one at the summit, subtracting the one amount from the other, and making an allowance for the difference of temperature in the two places, as indicated by the thermometer.

As the air varies in elasticity according to its temperature, the barometer falls during the warmest part of the twenty-four hours and rises during the coldest. These are called the horary variations of the barometer.

In our latitudes, N. and N.E. winds raise the barometer; S. and S.W. winds lower it. Steady winds, as the trade-winds, do not affect the barometer. In the tropics it is comparatively steady; in the temperate climates ever varying.

The barometer stands highest during a long frost. Fair or steady weather can seldom be expected when the barometer is below thirty inches. Previous to heavy gales and storms it sometimes suddenly falls to twenty-eight inches. In summer, during serene weather, a sudden fall of the barometer indicates a thunder-storm.

A morning, however fair and beautiful, cannot be depended upon with a low barometer; but very dense and dark threatening clouds will often pass away if the barometer is steadily high.

A sudden and extreme change of temperature, either from hot to cold or the reverse, is generally followed by rain.

The *Aneroid barometer* is an instrument which measures the elasticity of the air by means of a box with a vacuum and an elastic lid, which yields alternately to the pressure or relaxation of the air.

The *Sympiesometer* is another instrument which measures the tension of the air by its pressure on a portion of hydrogen gas, confined in a tube by means of oil.

THE THERMOMETER,

(ϑερμη, heat—μετρον, a measure),

Is a small tube of glass with a bulb at one end, which bulb, and part of the tube, are filled with mercury. The mercury in the bulb expands or contracts according to the degree of heat of the surrounding air; and this movement is measured by degrees or divisions on an index.

Fahrenheit's scale is that adopted in this country. Its zero, 0, begins at a degree of cold produced by mixing salt and snow. Water freezes at 32°, and boils (the barometer being at 30 inches) at 212°. 55° is temperate, 86° summer heat, 98° blood heat.

The *Centigrade* thermometer, used generally in Europe, is divided, as its name implies, into 100°, from the point that water freezes to the point where it boils. This is the most scientific scale, and deserves to be universally adopted.

Degrees of cold below Fahrenheit's zero, (0,) are marked with a sign, minus, thus — *5°*, *i. e.*, five degrees below zero.

Self-registering thermometers are so adjusted as to indicate of themselves the extreme point of cold and of heat during the twenty-four hours.

In taking the mean temperature of the twenty-four hours, it is found that the best periods for taking observations are half-past 8 A.M., and 9 P.M. The mean of these two observations will give the mean temperature of the day, month, or year.

As water boils at a lower point when the pressure of the air is much lessened, the thermometer has also been used to ascertain the elevation of mountains. Thus water boils at one degree less than 212° for every 555 feet of ascent, making corrections for the difference of temperature.

In ascending into the atmosphere, the thermometer usually falls 1° for every 300 feet of ascent.

In descending into mines that are being wrought, the temperature is found to rise one degree for every 45 to 60 feet of descent; but this rate is variable, and liable to modifications.

THE MARINER'S COMPASS

Consists of a magnetic indicator balanced upon a pivot, with a card below marked out into the various divisions of the circle. The N. pole of the magnet points nearly N., with a varying range of several degrees W. or E.; in this country several degrees W. of N. The magnetic poles N. and S., do not exactly correspond with the poles of the earth; the N. magnetic pole being in lat. 70° N., lon. 97° W., the S. pole is in lat. 75° 15′ S., lon. 154° 8′ E. The magnetic meridian is consequently a line having a direction from N.N.W. to S.S.E.

THE RAIN GAUGE

Is simply a funnel of a few inches square at the top, and terminating in a glass tube, graduated into inches and parts of an inch, for ascertaining the quantity of rain which falls in a given time on the surface. The glass tube is examined at certain intervals, and the amount of rain noted. A simpler instrument is made by Bryson of Edinburgh.

The rain gauge should be placed in an open exposed place, free from any eddy, or the shade of trees or houses. The elevation above the sea should also be noted. In general more rain falls close to the earth's surface than higher up.

THE HYGROMETER,

(ὑγρος, moist—μετρον, a measure),

Is an instrument for ascertaining the amount of moisture in the air. A piece of catgut, a hair, or awn of barley, will twist up in a dry air, and relax in a moist; and when coiled round the axle of an index, will form a hygrometer. But the best is Daniell's, which indicates the dew point by a condensation in the cooled-down surface of a bulb of glass.

The teacher should possess himself of the above-mentioned instruments, and accustom the pupils to the daily use of them.

V.

TABLE OF THE SNOW LINE.

NORTHERN HEMISPHERE.	Lat. N.	Elevation in English feet.
Dhawalagiri,	30°	15,000 south side. 16 to 18,000 N. s.
Bolar M.,	35	17,000
Ararat,	39	16,000
Pyrenees,	43	9,000
M. Blanc,	45	8,500
Interior of Norway,	60	5,000 4,000
Mageroe,	70	2,000

SOUTHERN HEMISPHERE.	Lat. S.	Elevation in English feet.
Equatorial Region,	mean of	15,748
Bolivia	16° to 18°	17,000
Central Chile,	33°	14,000 15,000
Chiloe Island,	42	6,000
Tierra del Fuego,	54	3,000 4,000
Victoria Land, Antarctic Ocean,	70	Sea level.
Franklin Island, Do. Do.,	76	

VI.

TABLES OF TEMPERATURE.

EUROPE.	Latitude North.	Mean Winter.	Mean Sum.	Mean of Year.	An. Rain in Inches
Jakutsk, Siberia, . .	62° .1	-36.3	61.7	13.5	
Tornea, Lapland, . .	66 .24	6.5	57.9	31.	
Irkutsk, Russia, . .	52 .17	0.9	61.5	32.6	
Umea, Sweden, . .	63 .50	13.5	57.4	35.3	
St Petersburg, . .	59 .56	18.6	61.6	39.6	16.
Moscow, ...	55 .45	15.2	64.	40.	
Christiania, . . .	59 .55	23.2	59.8	41.5	
Scandinavia, W. Coast, .	63 .				82.
Stockholm, . . .	59 .21	26.	60.4	42.2	
Leipzig, ...	51 .20	31.8	60.2	46.4	
Copenhagen, . . .	55 .41	31.3	62.7	46.5	
Breslau, ...	51 .7	29.2	63.6	46.7	
Danzig, ...	54 .20	30.	61.9	45.6	
Berlin, ...	52 .30	31.5	64.5	48.2	
Geneva (elev. 1,450 ft.), .	46 .12	34.	70.3	52.7	
Neufchatel, . . .	46 .59	35.7	66.5	51.	
Alps, S. declivity, . .	44 .				57.
Do., N. do., . .	46 .				35.
Vienna, ...	48 .13	31.9	69.4	51.	
Brussels, ...	50 .51	38.	64.	50.	
Paris, ...	48 .50	37.8	64.6	51.3	21.
Turin, ...	45 .11	33.4	71.5	53.1	
Trieste, ...	45 .38	39.4	71.4	55.3	
Bordeaux, . . .	44 .50	43.1	71.1	57.	
Madrid (elev. 1,994 ft.), .	40 .25	43.1	76.4	58.1	29.8
Marseilles, . . .	43 .18	45.2	72.9	58.3	
Rome, ...	41 .54	46.7	74.2	60.5	39.
Naples, ...	40 .52	47.6	74.3	60.2	
Florence, ...	43 .46	43.8	74.6	59.2	
Genoa, ...	44 .24	47.3	75.1	61.	
Constantinople, . .	41 .	40.9	71.3	56.5	
Lisbon, ...	38 .42	52.5	70.9	61.4	
Gibraltar, . . .	36 .7	57.9	77.8	67.4	
BRITISH ISLANDS.					
Plymouth, . . .	50°.22	44.9	60.9	52.1	36.9
London, ...	51 .30	39.3	62.8	50.6	24.
Liverpool, . . .	53 .24	41.3	61.1	50.8	
Manchester, . . .	53 .29	38.3	59.9	48.8	
York, ...	53 .40	36.2	62.3	49.2	23.6
Kendal, ...	54 .19	37.	57.8	47.	55.9
Isle of Man, . . .	54 .	41.7	59.0	49.8	

British Islands—*continued.*	Latitude North.	Mean Winter.	Mean Sum.	Mean of Year.	An. Rain in Inches
Edinburgh,	55°.57	38.4	57.2	47.1	24.
Makerston, Kelso,	55 .35	38.6	56.7	46.6	
St Andrews,	56 .19	39.2	58.9	48.6	
Glasgow,	55 .51	39.6	60.1	49.8	29.5
Perth, Kinfauns,	56 .23	37.6	57.2	46.9	30.9
Aberdeen,	57 .8	39.	59.5	49.2	27.4
Alford, Aberdeenshire,	57 .14			45.	37.9
Elgin,	57 .39	38.4	57.	47.7	24.
Inverness,	57 .28	35.	57.	46.	27.
Sandwick, Orkney,	59 .5	39.7	54.	46.2	
Cork,	51 .54				40.2
Castle-Comer,	52 .48				37.8
Dublin,	53 .23	39.8	59.6	49.	30.9
Belfast,	54 .36	41.4	63.9	52.3	34.9
Antrim,	54 .43	36.7	58.1	47.7	
ASIA AND AFRICA.					
Pekin,	39°.54	28.2	75.2	53.3	
Constantinople,	41 .	40.9	71.3	56.4	
Jerusalem (elev. 2,660 ft.),	31 .47	49.6	73.8	62.6	
Canton,	23 .8	54.8	82.	69.8	69.
Cairo,	30 .2	58.5	85.1	72.1	
Bagdad,	33 .21	49.6	93.1	73.7	
Seringapatam,	12 .45	71.3	74.9	75.7	
Benares,	25 .18	66.1	87.2	80.2	
Ava,	21 .50	68.8	83.6	78.4	
Calcutta,	22 .35	72.2	86.7	82.4	58.6
Bombay,	18 .56	77.4	82.8.	81.2	80.
Singapore,	1 .17	79.2	81.6	80.7	
Batavia,	6 .9 *S*	78.7	78.2	78.3	
Trincomalee,	8 .34	77.3	83.9	80.7	
Madras,	13 .4	77.0	86.2	81.9	48.
St Helena, (elev. 1,764 ft.),	15 .55 *S*	63.9	58.4	61.4	
Funchal, Madeira,	32 .38	63.5	71.6	67.6	29.8
Alexandria, Egypt,	31 .13	64.4	76.9	63.	
Tunis, N. Africa,	36 .48	55.8	83.	68.8	
Cape of Good Hope, S. Afr.,	34 .11 *S*	66.9	54.4	60.8	
Guinea,	8. 30	79.6	82.5	81.4	189.
Free Town, W. Africa,	8 .27	77.6	80.	79.3	
Cape Coast,	5 .8	67.1	68.7	67.9	
AMERICA AND AUSTRALIA.					
Melville Island,	74°.47	-28.5	37.	1.2	
Winter Island,	66 .11	-20.5	31.8	8.8	
Disco Island,	68 .	14.	47.1	31.5	
Fort-Franklin,	65 .12	-16.7	50.2	17.2	
Quebec,	46 .48	14.1	68.	41.8	

America and Australia—*continued.*	Latitude North.	Mean Winter.	Mean Sum.	Mean of Year.	An. Rain in Inches
Halifax,	44°.39	21.	61.	40.1	
Montreal,	45 .31	17.8	71.4	45.8	
Toronto,	43 .40	25.4	64.6	44.8	
Boston,	42 .21	28.3	69.	48.5	
New York,	40 .43	30.1	70.9	51.6	36.2
Philadelphia,	39 .57	30.1	71.4	50.8	
New Orleans,	29 .58	55.8	82.	69.8	
Mexico (elev. 7,570 ft.),	19 .25	53.6	65.2	60.6	
Bermuda,	32 .20	58.8	75.2	67.4	
Quito (elev. 9,543 ft.),	0 .14 *S*	59.7	77.6	73.3	
Rio Janeiro,	22 .54 *S*	68.6	79.1	73.7	
Hobartown, Australia,	42 .53 *S*	42.1	63.	52.4	22.4
Auckland, New Zealand,	36 .51 *S*	50.7	66.9	58.6	
Port-Jackson,	33 .50 *S*	55.5	74.2	66.8	26.7

The above tables are selected from those of Professor Dove of Berlin, and other sources.

VII.

ELEVATIONS OF THE PRINCIPAL MOUNTAINS IN THE WORLD.

MOUNTAINS OF EUROPE.

	Feet above Sea level.
Mont Blanc, Alps,	15,810
Monte Rosa, Do.,	15,585
Jungfrau,	13,720
Pic Nethou, Pyrenees,	11,168
Lomnitz Peak, Carpathians,	8,779
Tochar Dagh, Turkey,	10,000
Mount Guiona, Greece,	8,239
Mount Parnassus, Do.,	8,068
Mount Helicon,	5,738
Monte Corno (Apennines),	9,521
Mount Velino,	7,851
Snae Haten (Scandinavia),	8,120
Cerro Mulahaçen, Spain,	11,660
Pic de Sancy, France,	6,188
Puy de Dome, Do.,	4,806
Monte Rotondo, Corsica,	8,767
Riesenkoppe, Germany,	5,394
Brocken, Hartz, Do.,	3,658

	Feet above Sea level.
BRITISH ISLANDS.	
Snowdon, Wales,	3,557
Cader Idris, Do.,	3,550
Carn Llewellyn, Do.,	3,471
Cross Fell, Cumberland,	3,383
Helvellyn, Do.,	3,313
Skiddaw, Do.,	3,038
Malvern Hills, Worcestershire,	1,444
Holyhead, Anglesea,	709
Dover Castle, Kent,	469
Ben Nevis, Inverness-shire,	4,368
Ben Macdhui, Aberdeenshire,	4,348
Ben Avon,	3,931
Ben More, Perthshire,	3,818
Schehallien,	3,564
Cairngorm, Banffshire,	4,095
Ben Lawers, Perthshire,	3,945
Ben Wyvis, Ross-shire,	3,720
Ben Lomond, Stirlingshire,	3,190
Bencruachan, Argyleshire,	3,670
Bass Rock, Firth of Forth,	420
Arthur Seat, Do.,	822
Goat Fell, Arran,	2,865
Cheviot Hills,	2,657
Hartfell, Peebles,	2,635
Lowthers, Lanarkshire,	2,522
Queensberry, Dumfries,	2,259
Pentlands, Edinburgh, Carnethy,	1,878
Macgillicuddy Reeks, Kerry, Ireland,	3,404
Sleive Donnard, Mourne M., Do.,	2,796
ASIA AND AFRICA.	
Kunchinginga, Himalaya,	28,178
Dhawalagiri, Do.,	26,862
Jumnautri, Do.,	25,500
Chamalari, Tibet,	23,929
Cabool Peak, Hindoo Koosh,	20,232
Pedrotallagalla, Ceylon,	8,280
Adam's Peak, Do.,	6,152
Lebanon, Palestine,	11,030
Mount Hermon, Do.,	10,000
Mount Horeb, Do.,	8,593
Mount Sinai, Do.,	7,498
El Bruz, Caucasus,	18,493
Mount Argæus, Asia-Minor,	13,197
Mount Olympus, Do.,	6,500
Demavend, Persia,	14,695
Ararat,	17,112
Mount Atlas (Marocco, Africa),	11,400
Abba Jarrat,	15,008
Table Mount., Cape of Good Hope,	3,816
Peak of Teneriffe,	12,172
Mount Ambotismene, Madagascar,	11,506

North and South America and Australasia.	Feet above Sea level.
Mount St Elias,	17,860
Mount Brown, Rocky Mountains,	15,990
Mount Washington, Alleghanies,	6,620
Popocaptepetl, Mexico,	17,720
Nevado of Toluco, Do.,	15,542
Agua, Central America,	15,000
Blue Mountains, Jamaica,	7,277
Sierra Merida, Venezuela,	10,000
Aconcagua, Chilian Andes,	23,910
Antisana, Ecuador,	19,137
Chimborazo, Do.,	21,424
Arequipa, Peru,	20,320
Itacolumi	5,750
Mount Sarmiento, Tierra del Fuego,	6,900
Mount Wellington, Australia,	6,500
Mount Edgecumbe, New Zealand,	9,630
Orohena, Tahiti,	7,000
Mount Erebus (Victoria Land, Antarctic Sea),	12,400
Mount Terror Do.,	10,880

Minute differences of altitudes occur from the variations of different observers, and the varying depth of snow. The above lists have been carefully collated.

VIII.

COMPOSITION OF ROCKS.

Igneous Rocks.

Granite is composed of quartz, felspar, mica. Syenitic granite has hornblende instead of mica, which imparts to it a darker colour.

Greenstone is composed of felspar and hornblende.

Basalt is composed of same materials, but more homogeneous, and crystallized into large six-sided prisms.

Porphyry has a basis of greenstone or felspar, in which crystals of felspar are irregularly disseminated.

Lavas are of various forms, generally more porous, but of the same composition as greenstones and porphyries.

Sedimentary Rocks.

Gneiss, mica-slate, chlorite-slate, clay-slate, are rocks formed in the sea from the sand and dust of other rocks, as granite and greenstone, disintegrated or worn down by the action of water and air. The older sedimentary rocks are called primary or *azoic*, because they contain no animal or vegetable remains.

Certain slates and limestones of the greywacke or silurian class of strata first begin to exhibit remains of animals of a peculiar description. Their strata are called *Palæozoic*, as containing remains of ancient existences.

Red sandstones, limestones, yellow sandstones, chalk, oolite, are termed secondary formations. They are full of the remains of shell molluscs, fishes, reptiles; and of vegetables formed into coal and lignite or fossil wood.

Tertiary strata are still more recent formations, consisting of friable limestone, gypsum, sand and clay, containing remains of shell animals, reptiles, birds and quadrupeds.

The common soil is composed of the sand and dust of rocks, containing the simple earths, *aluminum* or clay, *silex*, *quartz* or flint, lime, soda, and potass. To these earths are also added decayed vegetable and animal matters.

Metallic ores are found in granite, and in the older sedimentary rocks, as gneiss, greywackè; as also in limestone.

Gems are the purer earths crystallized, and are found also in granites, greenstones, and the older rocks. The diamond, amber, and a few others, are found in clay and gravelly sand.

Specimens of all these minerals, &c., especially those of the neighbouring locality, should be exhibited to the pupils; and they should be taught to collect, name, and arrange them.

IX.

LIST OF BOOKS.

After having obtained a general idea of the groundwork of the subject, the student will then be able to extend his knowledge by consulting some of the following works:—

Daniells' Meteorology, 8vo.
Kămtz' Meteorology, translated by Walker, 8vo.
Forster's Researches on the Atmosphere, 8vo.
Humboldt's Cosmos, vol. i. 8vo.
Lyell's Elements and Principles of Geology, 4 vols. 8vo.
Atlas of Physical Geography, by A. K. Johnston, folio; or smaller work, 4to.
Mrs Somerville's Physical Geography, 2 vols. 12mo.
Virgil's Georgics contain many accurate remarks and fine poetic descriptions of the phenomena of the atmosphere.
Thomson's Seasons also contain throughout the most vivid and faithful, and often sublime, descriptions of natural phenomena.
The 104th Psalm, as Humboldt remarks, is a sublime "Cosmos" of itself.

HINTS TO TEACHERS.

Sketches and diagrams may be extemporaneously made by the teacher, on a common black-board, or on black canvas, with common chalk, or coloured chalks. These may be easily made by mixing with pounded chalk or whiting a little red lead, or yellow ochre, or green verdigris, or lamp-black, adding a very small quantity of common paste dissolved in water (a small tea-spoonful of paste to half a cup of water), and then mixing them up, forming them into rolls, and allowing them to dry perfectly. These chalks may also be used for drawing diagrams on large sheets of brown paper, or, what is better, on common room paper, sized with a light ground, but before any figures have been imprinted on it.

The teacher should, on all occasions, direct the attention of his pupils to objects within the reach of their individual observation, and thus the ascertained heights of hills and spires, and the length of roads and streets, in the vicinity, may become useful and practical means of comparison with other more distant and larger objects. A few examples of comparisons of this kind have been given in the preceding pages.

Short notes of facts should be taken by the pupils; and a note-book, in which is to be recorded the facts and observations which are daily occurring, should be used by every student who has the least desire to make progress in knowledge.

FINIS.

MURRAY AND GIBB, PRINTERS, EDINBURGH.